An Investigation into the Solutions for Work-related Musculoskeletal Disorders in the Hairdressing Industry

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Ph.D.

De Montfort University 2010

ABSTRACT

Hairdressers' exposure to work-related musculoskeletal disorders (WMSDs) appears to be insufficiently described in the literature. Knowledge regarding musculoskeletal disorders in this group is also sparse.

The purpose of the research was to investigate the status of work-related musculoskeletal disorder cases found in Taiwanese hairdressers and to develop user-centred, strategic solutions to prevent the accumulation of musculoskeletal disorders in this group, especially newcomers to the industry.

The study involved a series of investigations into the status of WMSDs for hairdressers in Taiwan as a first step towards their prevention. A hairdresser-oriented, musculoskeletal questionnaire was used to discover the risk factors associated with WMSDs and a validated, on-line, rapid, upper-limb assessment tool was used to identify critical hairdressing working postures.

Improvements to the main critical hairdressing working postures identified by the first stage of the research have been addressed by an ergonomics training programme. The effectiveness of this is validated using 3D-motion analysis based on a pre- and post-test evaluation of awkward movements. A scientific approach to 3D-motion analysis has been achieved specifically by the study of the awkward working postures of the upper extremity during hair-blow-waving and hair-straightening activities.

The relationship between working postures and WMSDs in various body regions is discussed. In this regard, poor posture and movement can lead to local mechanical stress on the muscles, ligaments and joints, resulting in discomfort in the musculoskeletal system, particularly the neck, back, shoulder and wrist.

This research has provided a WMSDs prevention framework as a strategic method of securing a continuous improvement in the awkward working postures adopted during various hairdressing activities. Topics for further studies are suggested.

ACKNOWLEDGMENTS

Pursuing a Ph.D. project is both an enjoyable and painful experience. It is just like climbing a high peak, step-by-step, accompanied by bitterness, hardships, frustration, encouragement and trust and with so many people's kind help. Though it will not be enough to express my gratitude in words to all those people who helped me, I would still like to give my thousands of thanks to all these people.

First of all, I would like to give my sincere thanks to my honorific supervisor, Dr. Robert C. C. Chen. He offered me so much advice, patiently supervising me, and always guiding me in the right direction. Without his help, I could not have completed my thesis.

My sincere thanks go to the professional ergonomist Professor Li-Chieh Kuo and his Masters students Kuan-Y Lai and Yi-J Tsai in the Department of Occupational Therapy, National Cheng Kung University. Without their support, it would not have been possible for me to pursue and to complete this Ph.D. project successfully. I particularly thank Professor Li-Chieh Kuo for permission to use his 3D-Motion laboratory for the research.

I would also like to acknowledge the help given by Dr. Qin Xu and Professor H. J. Yang. My thanks also go to my colleagues, Tony Chien-Bang Chen and Wen Nivala, Shi-Wei Liu and Chia-Hung Hsu for their special help throughout this research.

My sincere thanks go to the department and my colleagues in the Department of Styling & Cosmetology in Tainan University of Technology, which gave me indispensable generous sponsorship. Without their support and financial help, it would not have been possible for me to pursue and to finish this Ph.D. project successfully.

I am very grateful to my parents, sister Hsiao-Ping Fang and brother Chun-Chiang Fang. Their understanding and love encouraged me to work hard and to continue pursuing a Ph.D. project abroad. They always lets me know that they are proud of me, which motivates me to work harder and do my best.

I am greatly indebted to my husband Ken Tin-Kai Chen and my son Tai-I Chen. They form the backbone and origin of my happiness. Their love and support without any complaint or regret has enabled me to finish this Ph.D. project. I am very grateful to Tai-I, for being willing to forgo his mother's attention while she was preoccupied with the research.

Last but by no means least, a very special thanks must go to Mr. Howard Billam who has helped me by proof reading this thesis.

Hsiao-Lin Fang

Leicester, 29th July, 2010

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Chapter One: Introduction

1.1. Background

This research focuses on an investigation into work related musculoskeletal disorders (WMSDs) in the hairdressing industry in Taiwan. The outcome of this research will provide a validated and user-centred framework for work-related, musculoskeletal disorder prevention which can benefit trainee hairdressers in the educational system in Taiwan. It will discuss the relationship between working postures and WMSDs in various body regions. In this regard, poor posture and movement can lead to local mechanical stress on the muscles, ligaments and joints, resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system (Dul and Weerdmeester, 1993). This is because, when maintaining a posture, the joints must be kept in a neutral position with the limbs, as far as possible, close to the body, thus enabling the muscles to deliver the greatest force.

1.1.1. Hairdressing exposure to Work-related Musculoskeletal Disorders

Hairdressers' exposure to work-related musculoskeletal disorders appears to be insufficiently described in the literature, and knowledge regarding musculoskeletal disorders in this group is also sparse, although some research has been conducted (e.g. Veiersted *et al*., 2008). Leino *et al*. (1999) mentioned that chemical and ergonomic work factors cause significant discomfort and even work-related diseases for the workers in the salons, with the musculoskeletal system being at greatest risk. English *et al.* (1995) studied 580 cases and 996 controls; the diagnoses of the cases included soft tissue conditions affecting the shoulder, elbow, forearm, wrist, thumb, hand and fingers whilst the controls included traumatic, degenerative and inflammatory conditions, mostly of the legs and lower back. The risk was found to be highest for shoulder cases amongst female hairdressers. The following sections describe the statistics related to work-related musculoskeletal disorders in the U.K. and Taiwan:

In the U.K., the Hairdressing and Beauty Industry Authority (HABIA) is one of the most important bodies affecting hair, beauty therapy and nail workplaces. According to a survey of the hairdressing industry by HABIA in 2008, it employs 245,795 people. There are over 35,000 salons in the UK, with an annual turnover in excess of £5.25 billion.

In Taiwan, according to data from Taiwan's Bureau of Labour Statistics, more than 30,000 hairdressers and barbers were employed at salons or barbershops (Taiwan DGBAS, 2010). In fact, there have been few case studies in Taiwan which have studied MSDs and schemes for their prevention.

In 1988, an investigation reported through the National Health Interview Survey was analysed by Guo (2002), who pointed out that of the top 15 major occupations, female hairdressers and cosmetologists are the third most risky for lower back pain attributable to work. In 2004, a nationwide study was conducted in Taiwan with a standard questionnaire distributed to a representative sample of 22,475 non-self-employed workers (Guo *et al.,* 2004). Among the 18,942 who returned the questionnaire, 37.0% had musculoskeletal disorders. Many of these cases were claiming compensation from labour insurance, of these, hairdressers were making the most claims for upper limb disorders from 1999 to 2001 (Lin, 2003).

1.1.2. Work-related musculoskeletal disorders in various body regions

Hairdressers are artists who seek to design a hairstyle after discussion with their clients. However, they need to move their body to fit the height of the washbasin and adjust the styling chair to fit the length of a client's hair when using hair cutting, blow-drying or perming techniques. Thus, WMSDs are known in the hairdressing industry and could be caused by repetitive movements, the need to hold body movements for long period of time and the awkward positions required to perform the techniques needed to meet the client's expectations. The height of the hairdresser, the sitting height of the client and the length of the clients' hair are all variables.

Wu *et al.* (2004) conducted a questionnaire survey given to 36 hairdressers from thirteen hair salons as part of a study of the musculoskeletal disorders in employees working in beauty salons in Kaohsiung, Taiwan. The results of this survey revealed that most of the discomfort comes from the shoulders (94.4%), lower back (80.6%) and neck (77.8%). Furthermore, a similar result from a quantitative study (n=360) by Chuang (2005), found that 94.4% of hairdressers voted that their shoulders were the most uncomfortable body region, followed by the lower back and neck. In short, it is obvious that most research into WMSDs indicates that hairdressers suffer from discomfort in their upper limbs, neck, shoulders, lower back and wrists.

1.2. Motivation

1.2.1. Essence of ergonomics for hairdressers

Many MSDs related to the physical risk factors for hairdressing have been found in the literature. The relationship between hairdressing and the development of work-related musculoskeletal disorders, however, remains unknown. The literature does suggest that prolonged working as a hairdresser may increase the risk of work-related musculoskeletal disorders.

Ergonomics began as an applied science concerned with people at work (Nicholson and Ridd, 1988). In 2006, Pheasant and Haslegrave (2006) pointed out that the ergonomic approach may be summarized in the principles of a user-centred framework and has to consider all the relevant factors such as comfort, health and safety. Fitting the hairdressing job to the hairdressers involves the consideration of health and the quality of working life just as much as productivity. In addition, the efficiency and quality of performance are influenced by the techniques which a hairdresser uses as well as by their working environment, as shown in Figure 1.1 below.

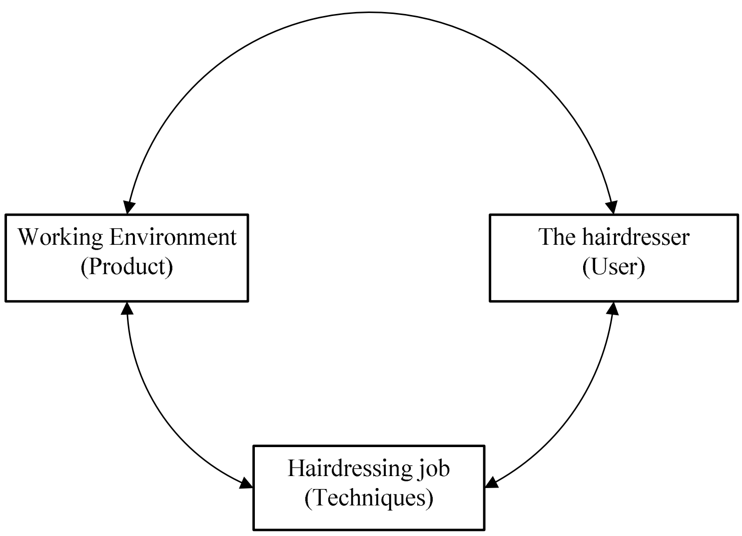

Figure 1.1. User-centred framework for the hairdressing industry.

The user-centred framework can be characterized in terms of the features identified by Nicholson and Ridd (1988): firstly, the user-centred framework is empirical; it is based on direct observations of human beings and their behaviour, supported by systematic investigations of human experience. Second, the user-centred framework is iterative: it is a cyclic process in which a design phase alternates with a phase of empirical analysis and evaluation. Third, the user-centred framework is non-procrustean: it aims to modify the product to fit the user, rather than *vice versa*, and is concerned with people as they are rather than as they might be. Lastly, a user-centred framework takes due account of human diversity: it attempts to achieve the best possible match for the greatest number of people so far as is reasonably practicable within constraints of cost, etc. Moreover, Pheasant and Haslegrave (2006) added two more features of user-centred frameworks, namely, that they are systems-orientated and pragmatic. Furthermore, the object is to achieve the best possible match between the product (object, system or environment) being designed and its user, in the context of the (working) techniques that are to be performed. In other words, the user-centred framework is the science of fitting the job to the worker and the product to the user.

Expanded from the above user-centred theories, the ergonomic knowledge for the prevention of WMSDs for hairdressers can be defined as in Figure 1.2.

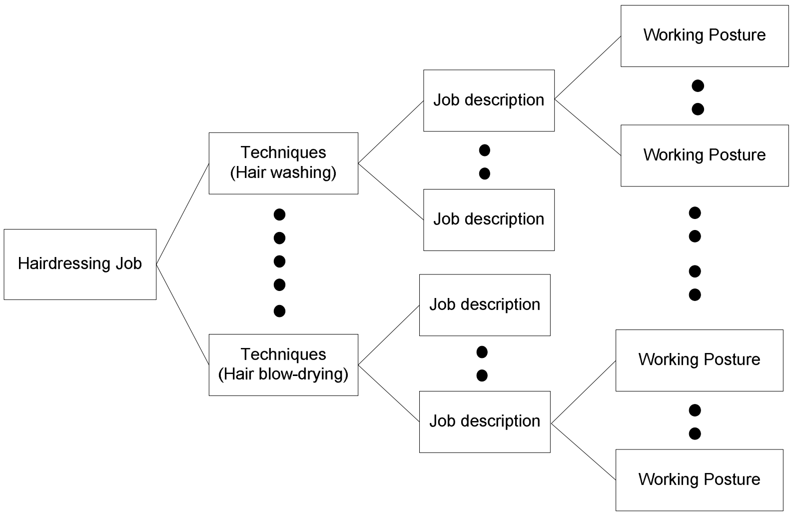

Figure 1.2. Ergonomic knowledge of the relations between the hairdressing job, techniques, job description and working postures.

As can be seen, there is a relationship between the hairdressing job, techniques, job description and working postures. In a real work situation, a hairdresser is required to perform various daily tasks to fulfil his/her job in order to satisfy the client's needs. Each technique consists of various hairdressing tasks and the associated working postures to complete the overall task. This implies a dynamic working posture to utilize various body regions skilfully when using the appropriate equipment. If an awkward working posture occurs whilst performing the daily task, the discomfort could be cumulative and result in WMSDs in specific body regions.

It is clear that, without understanding the ergonomics of WMSDs prevention at work, the user-centred framework could create a development cycle of WMSDs that impacts on the hairdressers' job of satisfying the customer's needs, as shown in Figure 1.3.

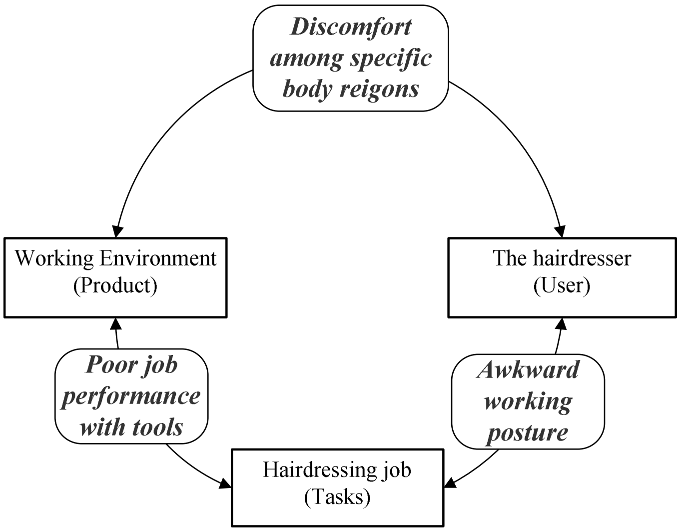

Figure 1.3. The development cycle of WMSDs with hairdressers who are not aware of the essence of the ergonomic knowledge.

For instance, the techniques are varied in duration or repetition among all the techniques and the job description, this is because hairdressing techniques are not systematic, which makes analysis difficult. Repetition and duration will not be repeated or recycled in each sub-technique; they will depend on the variable, such as hairstyle, as discussed in the above paragraph. Somehow, according to a hairdresser's ability to be creative, they might develop and create a way of hair cutting which might also cause them great discomfort without ever knowing it. Thus, there is a relationship between the user-centred framework and ergonomic knowledge.

1.2.2. 3D-motion analysis of the risks involved in certain hairdressing techniques

Hairdressers suffer musculoskeletal discomfort, injury and harm, which may result in not only decreased job performance and lower productivity, but also increased time off work and early retirement from this profession (Fang *et al.*, 2007; Wu *et al.*, 2004; Chuang, 2005). The research findings reveal various forms of discomfort in body regions, however, as hairdressers work in different ways and use different techniques, a key question is how to decrease this discomfort whilst at the same time identifying how to improve their techniques of posture and movement without affecting the look of the hairstyle. From this point of view, the strategy for prevention of WMSDs and the evaluation of training effectiveness will make a contribution to this industry.

WMSDs leading to discomfort, pain or injury among hairdressers have been found in many countries. Observation and sEMG are typically used for the study of hairdressing work. With regard to observation in recent studies, earlier research conducted by Tammiene-Peter *et al.* (1985) found that the techniques which caused strain in the musculoskeletal system of hairdressers, were, in increasing severity: rolling, blow-drying, cutting, and washing. They further discovered that haircutting and blow-drying were the worst techniques as regards causing strain on the upper extremities for Finnish hairdressers. Recently, Nevala-Puranen *et al.* (1998) conducted observations that studied hairdressers' work in the neutral position in their daily work techniques (washing, cutting, rolling and blow-drying).

Videotaping and computer-aided observational methods have been used and developed, such as the portable ergonomic observation method (PEO) by Fransson *et al.* (1995). However, direct measures are often associated with high cost, time consumption, subject interference and being difficult to perform for large sample sizes (Li and Buckle, 1999). In real work situations, the camera's position in relation to the operator can be continuously changed owing to operator movement, therefore the posture angles observed in videotape recording may not be the same as the ones in the real work situation (Li and Buckle, 1999). Furthermore, data on muscle activity (EMG), posture, repetition and activity were synchronized and available on the playback of the videotape. Some videotaping and computer-aided systems have the function of "direct posture/motion measurement" such as AutoGait 3D and 3D motion analysis. The cameras register the position of reflective body markers at a high frequency to capture kinematic data. These time-based coordinates can be integrated with analogue signal sources such as force platforms, EMG and other inputs.

As for the sEMG, recently, Chen *et al.* (2010) utilized a portable data-logger to measure the wrist angles and forearm flexor and extensor electromyography (EMG) of 21 hairstylists in Taiwan. Experimental results show that the average time to finish a woman's haircut (51.4mins) is significantly longer than that for a man's haircut (35.6mins). Female hairstylists had significantly greater EMG activity than male hairstylists. However, there is a lack of sEMG studies of hairdressing techniques in the research field.

From the methods discussed above, a choice of the method to be used for assessment has to be made, and the identification of hairdressing techniques is another issue that needs consideration when making an exposure assessment. With the same observational method, for example, different observers may still get different assessment results for the same job, because they focus on the assessment of different techniques within that job (Li and Buckle, 1999). Moreover, it may be reasonable to say that most of the existing methods developed for assessing exposure to potential musculoskeletal risks are research-orientated (Li and Buckle, 1999). They are based on the experts' view about which occupational risk factors should be considered, and how they should be measured. It is possible to say that this researcher's aim is to turn the theory of assessment exposure in hairdressing techniques into suitable assessment methods. However, hairdressers' needs might be completely different or they might misunderstand the ergonomists' intervention. Such confusions need to be considered in the future development of the exposure assessment methods that are able to combine both points of view.

Recently, motion analysis techniques have been successfully applied to a three-dimensional (3D) body movement model with the body movement being measured by 3D imaging techniques. In 1998, He and Tian (1998) pointed out that the automatic tracking of motion data recorded via a digital camera had facilitated human movement study. Petuskey *et al*. (2007) stated that 3D imaging techniques allow clinicians and ergonomists to measure the position of an extremity in space during the performance of simulated functional techniques. 3D imaging techniques also provide a way to document multi-planar functional limitations in the upper extremity. They suggest that the 3D imaging techniques are a good method for the statistical comparison of normal and abnormal participants, or for measuring outcomes during training intervention and treatment. Moreover, the observations using the 3D imaging techniques show that this parameter is easy to detect and is a clinically useful measure for the statistical comparison of populations (Petuskey *et al*., 2007). Furthermore, Carey *et al*. (2008) emphasized that data obtained from 3D imaging techniques can lead to the development of a kinematic model for a transradial prosthesis or as a training guide for upper limb prosthetic use during the activities involved in various working techniques. These imaging techniques have not been routinely used for this purpose primarily due to a lack of standardized protocols stemming from the complex nature of upper extremity motion (Barker *et al.*, 1996).

For hairdressers, although direct observation and sEMG studies have been implemented to identify the risk factors associated with work-related upper limb disorders (Veiersted *et al.*, 2008), the upper extremity joint excursions required to perform hairdressing techniques remain unknown since there have been no studies establishing a normative database of 3D kinematic values for hairdressing techniques.

1.2.3. Ergonomics training in hairdressing education system

In this research, the first consideration is that the development of the exposure assessment method will need to utilise the principles of ergonomics to systematically describe hairdressing techniques and, secondly, to introduce the concept of ergonomics into the hairdressing industry. However, there are some benefits that might be identified: firstly, is how WMSDs are affected by body space, the equipment and working space with relation to hairdressing techniques. Secondly, although the government in Taiwan has established a prevention programme in some industries, such as construction and semiconductor manufacture, there is nothing which addresses the risk factors for the hairdressing industry, even though there is evidence of obvious harm and risks among hairdressers in Taiwan (Wu *et al.*, 2004; Chuang, 2005; Fang *et al.*, 2007; Chen *et al.*, 2009 and Chen *et al.*, 2010).

St-Vincent *et al*. (2001) implemented participatory ergonomics training and ergonomic analysis tools in the manufacturing sector. In order to deal with training problems and learning difficulties, they provided a validated training intervention procedure and recommended useful analysis tools for the different contexts of both short-cycle repetitive techniques and long-cycle varied techniques.

In a participatory context, the first challenge for training people is the relatively short time in which the participant must acquire knowledge and understand basic concepts. In order to overcome this challenge, two key elements for intervention training were emphasized:

1. Development and facilitation of methods and tools that promote the emergence and expression of the participants' knowledge: especially interviews and questionnaires,

video-recording-supported discussion and the teaching of group work techniques.

2. Identification and improvement of risk factors: They emphasized that participants must be able to develop their intervention from an understanding of the actual work activity through the use of video recordings and the tools mentioned above.

It was mentioned earlier that the essence of the ergonomics of WMSDs prevention for hairdressers could be deemed to be a type of ergonomic intervention. In Taiwan, there is a lack of research into ergonomics training in the current hairdressing education system. Furthermore, the way to evaluate the effectiveness of such training is unknown. Therefore, a comprehensive literature review needs to be carried out for the proposal of an adaptive training procedure and related methods/tools for the prevention of WMSDs among hairdressers in Taiwan. In addition, the evaluation of both risk factors and learning effectiveness must be carried out.

1.3. Aims and Objectives

The purposes of the research are to investigate the status of work-related musculoskeletal disorder cases found in Taiwanese hairdressers and to develop user-centred strategic solutions to prevent hairdressers, especially newcomers, from accumulating musculoskeletal disorders. This research will provide a WMSDs prevention framework as the strategic solution that secures a continuous improvement of the awkward working postures adopted during the functional activities of the various daily hairdressing techniques. The areas of the study will involve a sequence of investigations into the status of WMSDs for hairdressing in Taiwan as a first step leading towards their prevention. A hairdresser-oriented questionnaire will be used to discover a wider range of the risk factors for WMSDs among Taiwanese hairdressers and a validated, on-line, Rapid Upper Limb Assessment (RULA) tool will be used to identify critical hairdressing working postures. In this research, the top critical hairdressing working postures identified by the investigation will be improved by the implementation of an ergonomic training programme. The effectiveness of the training will be validated using 3D Motion Analysis based on a pre- and post-test evaluation of awkward movements.

The objectives of the research are:

- To review the relevant literature concerning the subject areas of WMSDs for working postures, relating to working conditions, body discomfort, hairdressing techniques, tools and equipment and ergonomics training.
- To identify Taiwanese hairdressers' risk factors for work-related musculoskeletal disorder injuries within the hairdressing industry through the use of questionnaires to address hairdressing techniques and the levels of discomfort in various body regions.
- To observe and record hairdressers' professional activities and environment in order to identify working postures relating to the MSDs among hairdressers.
- To implement 3D motion analysis and the associated cycle task analysis to validate the effectiveness of the ergonomics training for the study of right-upper-limb kinematics during the functional activities involved in hair-blow-waving and hair-straightening techniques, based on pre- and post-testing and the evaluation of awkward movements.
- To generate and validate the relation between the risk factors identified by the questionnaire survey and those identified through observation.

- To evaluate the improvement due to training, draw the conclusions, set out the original contributions to the research areas and identify the areas requiring further research.

1.4. Methodology

1.4.1. Documentary research

A general literature search related to the subject areas was undertaken and summarized into three parts: Firstly, the terms and definitions of bones and muscles are described in Chapter 2.1. The current development of WMSDs prevention policy is summarized in Chapter 2.2 and the background information on the risk factors for WMSDs among hairdressers is reviewed in Chapter 2.3. Thirdly, risk factors associated with techniques and working posture will be reviewed in Chapters 2.4 and 2.5. Finally, the background information on the ergonomics training programme associated with hairdressing and manual-handling jobs will be reviewed in Chapter 2.6. These sections will help to develop a sequence for an investigation into the status of Taiwanese hairdressers and the implementation of the ergonomics training programme for the improvement of the awkward working postures adopted when using the various daily hairdressing techniques.

1.4.2. Methodology

In Figure 1.4, a framework is given to illustrate the research structure and the relationship between the chapters.

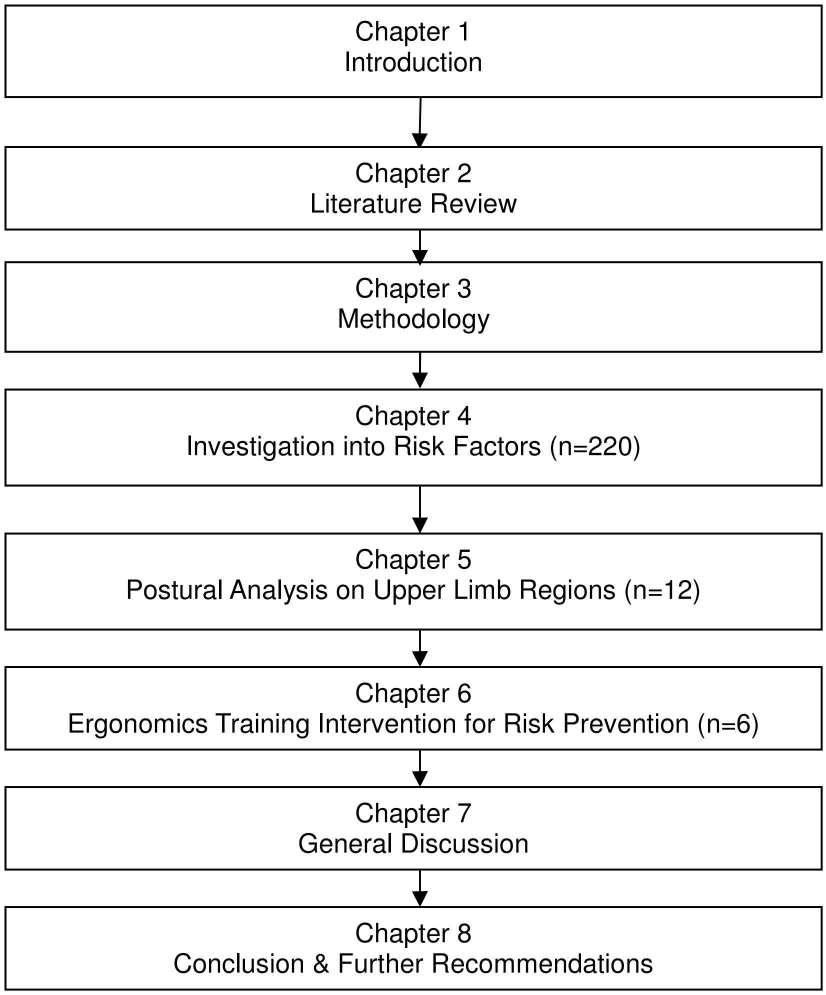

Figure 1.4. The framework of the research.

The methodology proposed in Chapter 3 is based on a modified TIER model. The background information regarding the modified TIER model and associated methods are discussed. These methods are risk-evaluation methods related to the Nordic questionnaire survey, RULA and the 3D motion analysis. The methodology consists of three parts, one for each of the three primary studies: investigation into risk factors in Chapter 4, postural analysis of the upper limb regions in Chapter 5 and ergonomics training intervention for risk prevention in Chapter 6.

These three primary studies (Chapters 4, 5 and 6) are summarized as follows:

- Investigation into risk factors: A hairdresser-oriented musculoskeletal questionnaire will be designed and validated, based on recent studies of the Nordic Musculoskeletal Questionnaire (NMQ), presented by Kuorinka (1987). The NMQ has been modified and widely applied to other similar occupations, such as restaurant workers in Taiwan, by Chen *et al.* (2003), and forestry workers in Finland, conducted by Miranda *et al.* (2001).
- Posture analysis of the upper limb regions: Following the questionnaire survey, hairdressing techniques will be observed via digital video recorders (DVs). Based on the RULA analysis, it is possible to evaluate the risk level of hairdressing techniques and, in turn, to identity critical hairdressing techniques for further improvement of related awkward working postures.
- Ergonomic training intervention for risk prevention: The most critical hairdressing techniques will be improved based on the implementation of the ergonomic training programme within an academic semester (i.e. sixteen weeks). The training effectiveness will be evaluated using 3D motion analysis.

1.5. Related Work

Risk factors causing significant discomfort and even work-related diseases for the workers in the salons include repetitive movements, awkward working postures, standing, draughts, uncomfortable temperatures and the use of chemicals, tools and equipment. (Leino *et al.*, 1999). For instance, scissors are an essential hand tool for any hairstylist. The repetitive use of the fingers and forearms in any scissoring operation places a great deal of stress on the tendons that run through a carpal tunnel. Therefore, Chiavaras and Neimken (Boyles *et al.,* 2003) designed hairdressing scissors that incorporate some of the characteristics of an ergonomically designed tool. Although this study did not involve improving the tools and working environments, these should be considered as part of the risk-prevention strategy in a continuous improvement process.

This research study argues that the investigation into the status of WMSDs among hairdressers should be taken as the first step towards risk prevention. In fact, ergonomics training for the prevention of WMSDs has been studied for many years in several occupations. This indicates the importance of posture in ergonomic training for the improvement of working techniques (Veiersted *et al.*, 2008). However, there has been a lack of research in the field for hairdressers. Therefore, this study highlights that ergonomics training must be integrated into academic hairdressing courses in Taiwan, especially to benefit newcomers to the industry.

1.6. Summary

The introductory Chapters, 1 and 2, give a brief review of the risk factors of WMSDs among hairdressers and manual handling workers and will also provide the methods for the primary studies, including the questionnaire survey, observation, the ergonomic training programme and 3D-motion analysis.

Chapter 3 will use a modified TIER model as the foundation of the methodology of this research. The model will provide researchers with practical knowledge of training research design and consistency, and with a reliable reference point for launching other investigations. The model systematically structures training effectiveness research across the three primary studies in this research.

Following the initial study, Chapter 4 will describe a questionnaire survey based on a revised hairdressing musculoskeletal questionnaire that indicates questions about the relationship between hairdressing techniques and the discomfort felt in various body regions. A much larger number of participants, i.e. 220 professional hairdressers located in different regions in Taiwan is used. First, a pilot study for the initial risk factor exploration and the evaluation of the reliability of the questionnaire design was undertaken (n = 12). The findings of the pilot study have been published at an international conference (Fang *et al.*, 2007) and explore whether the techniques of hair-washing, blow-drying and hair-cutting are associated with the highest overall discomfort felt in the lower back, right-shoulder and neck. Based on the findings of the questionnaire, these techniques were recommended for further investigation in the next study.

In Chapter 5, an observational study using a video recorder was employed to observe hairdressers' daily techniques. An on-line RULA validation tool was used to evaluate the risk level of hairdressing techniques and associated working postures identified from static photos. As a result, 21 critical hairdressing working postures were identified.

Having ranked the risk level of these critical hairdressing techniques, three of the most critical were found to be hair-washing in the washbasin area, followed by hair-straightening and hair-blow-waving, which is consistent with the results of the previous study.

Chapter 6 describes how an ergonomics training programme involving lecturing and group training with participants (i.e. 3 with hair-blow-waving techniques, and 3 with hair-straightening techniques) was integrated into a hairdressing course within an academic semester (i.e. sixteen weeks) in the Department of Cosmetology and Styling at Tainan University of Technology. The pilot test and the evaluation test were conducted before and after the hairdressing course to identify any improvement in awkward postures. 3D-motion analysis was employed to quantitatively record the 3D body movement of hair-blow-waving and hair-straightening techniques over the top of the manikin head for participants in the Department of Occupational Therapy, National Cheng Kung University, Taiwan. The results, findings and limitations of the 3D motion analysis were discussed and later published at an international conference (Chen *et al.*, 2009). It is hoped that this study will facilitate the use of 3D motion analysis techniques to analyse the processes involved in hairdressers' working techniques.

Chapter 7 will discuss the risk factors that are related to each other and many results from the primary studies that have been undertaken. Chapter 8, the concluding chapter, gives a summary of the research findings and highlights the problems that occurred during the study. The recommendation will be made for the Ministry of Labour, hairdressing companies and the training and education system in Taiwan.

Chapter Two: Literature Review

2.1. Terms and Definitions

2.1.1. Posture of the human body

Before talking about the posture of the human body, its movement relating to joints, bones and muscles should be introduced first.

The universally used method of describing human movements is based on a system of planes and axes (Figure 2.1). The three cardinal planes that originate at the centre of gravity are the sagittal plane, which divides the body into right and left; the frontal plane, dividing the body into front and back; and the transverse plane, dividing the body into top and bottom. Movement takes place in or parallel to the planes about a mediolateral axis (sagittal plane), an anteroposterior axis (frontal plane), or a longitudinal axis (transverse plane), as shown below (Figure 2.1) (Hamill and Knutzen, 2003).

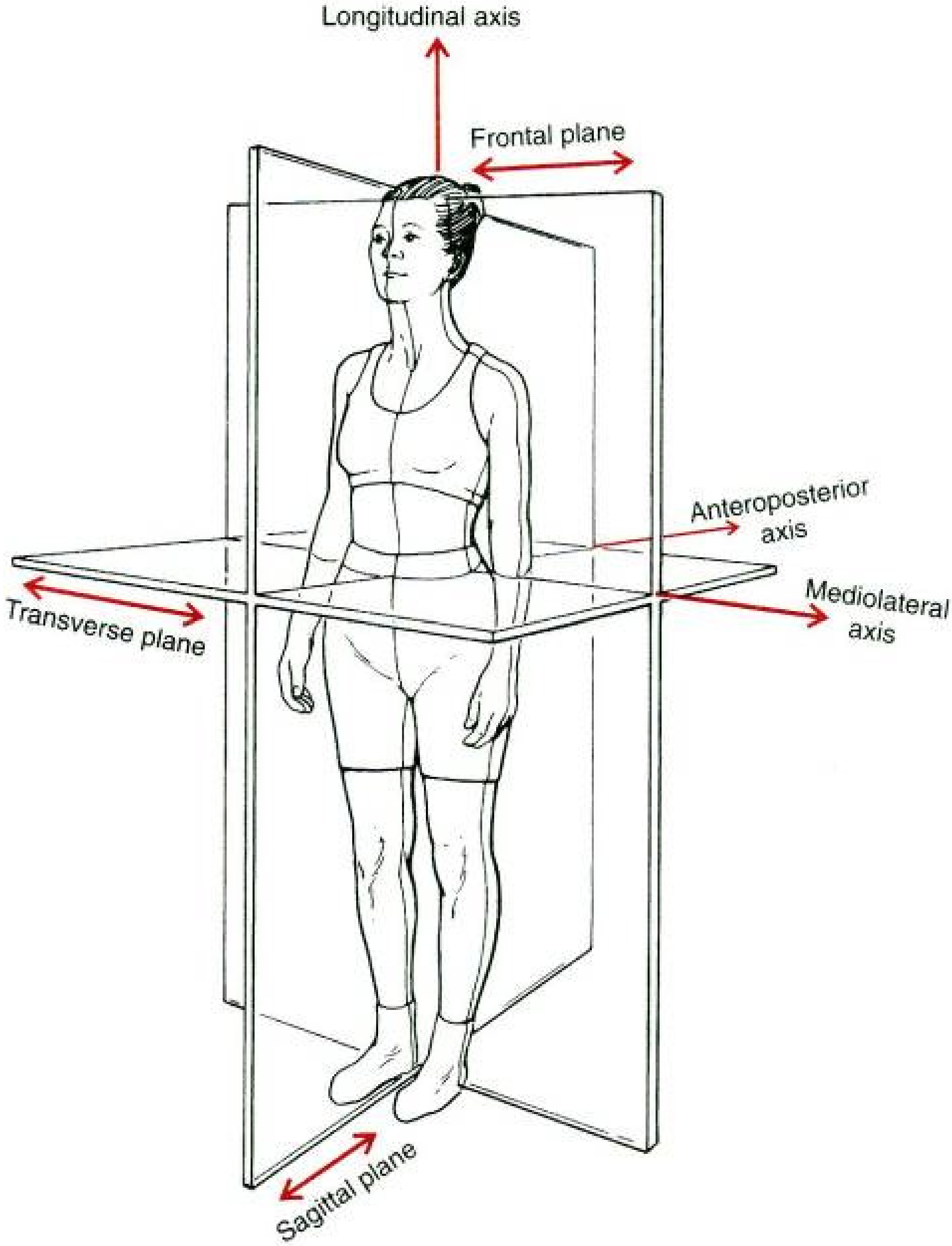

Figure 2.1. Planes and axes
(Source: Hamill and Knutzen, 2003).

Six basic movements occur in varying combinations in the joints of the body. The first two movements, flexion and extension, are movements found in almost all of the freely movable joints in the body. These movements are described in the following sections:

2.1.2. Flexion and extension

Flexion is a bending movement in which the relative angle of the joint between two adjacent segments decreases. Extension is a straightening movement in which the relative angle of the joint between two adjacent segments increases as the joint returns to the zero or reference position (Hamill and Knutzen, 2003). The movements of the hand and fingers are illustrated in Figure 2.2, and the movements of the flexion/extension of the head, arm, forearm and trunk are illustrated in Figure 2.3.

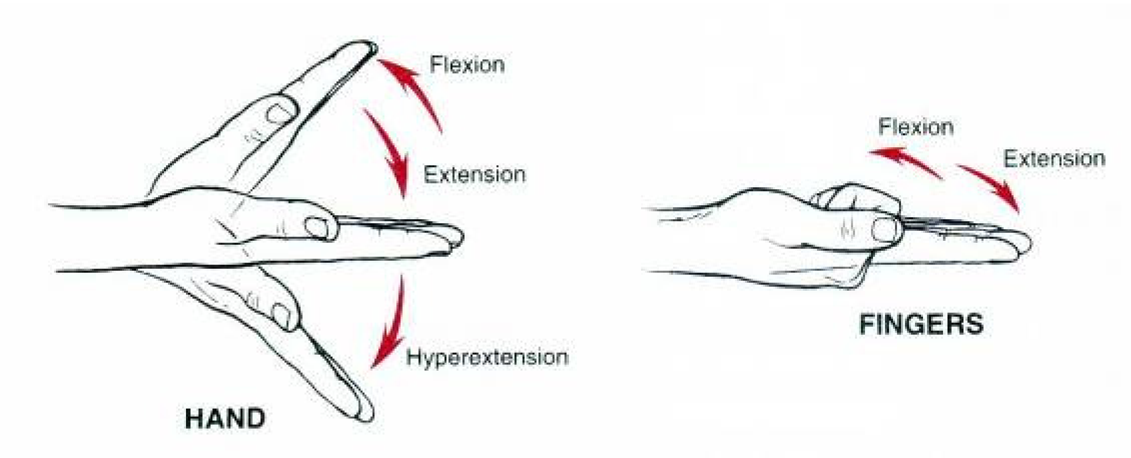

Figure 2.2. Flexion/extension of the hand and fingers
(Source: Hamill and Knutzen, 2003).

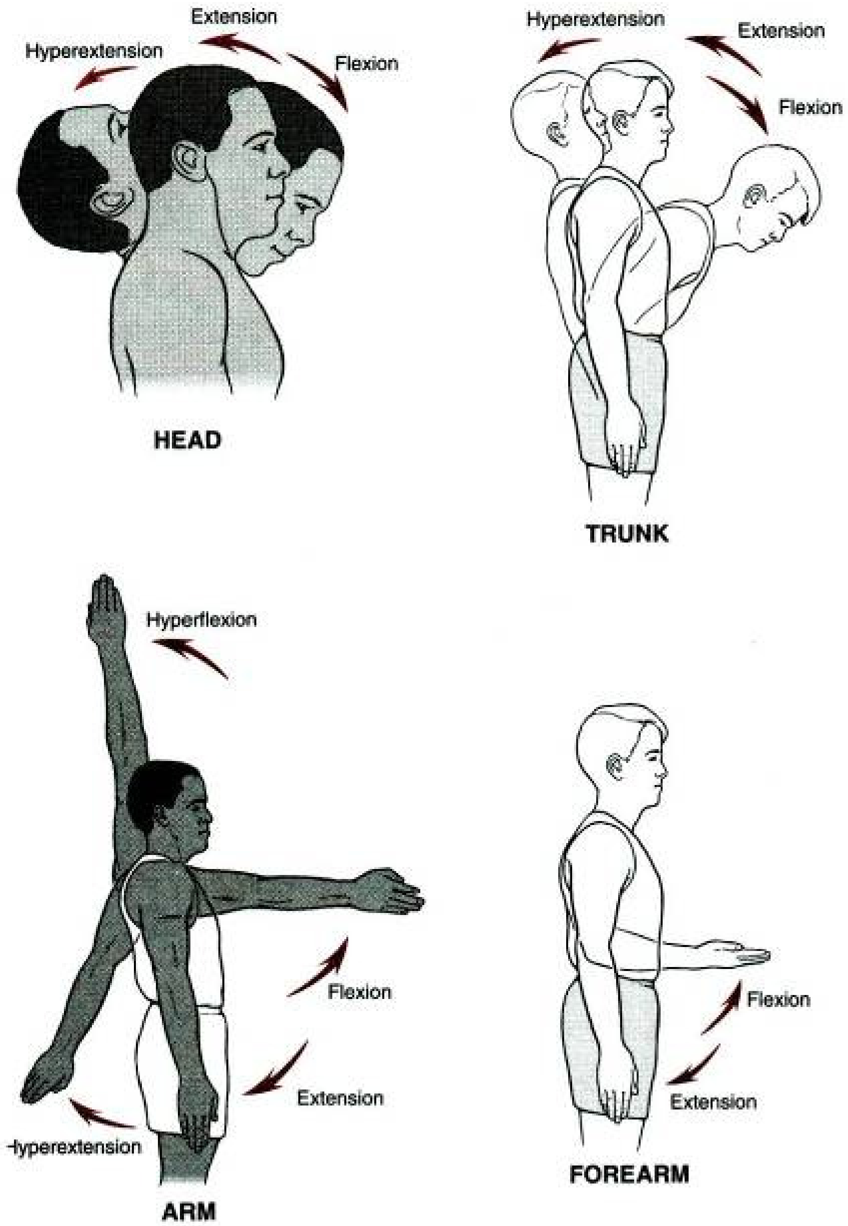

Figure 2.3. Flexion/extension of the head, arm, forearm and trunk.

(Source: Hamill and Knutzen, 2003).

2.1.3. Abduction and adduction

The second pair of movements, abduction and adduction, are not as common as flexion and extension; abduction is a movement away from the midline of the body or the segment (Figure 2.4). Raising an arm or leg out to the side or the spreading of the fingers or toes is an example of abduction (Figure 2.5). Adduction is the return movement of the segment back toward the midline of the body or segment; bringing the arms back to the trunk (Hamill and Knutzen, 2003).

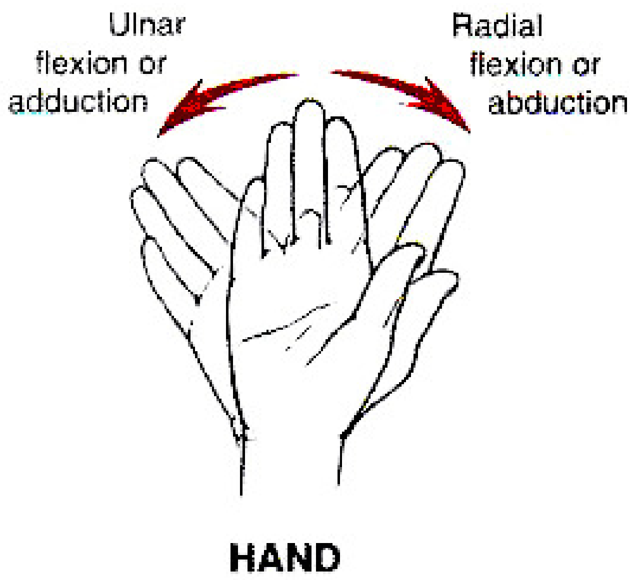

Figure 2.4. Abduction / adduction of the hand
(Source: Hamill and Knutzen, 2003).

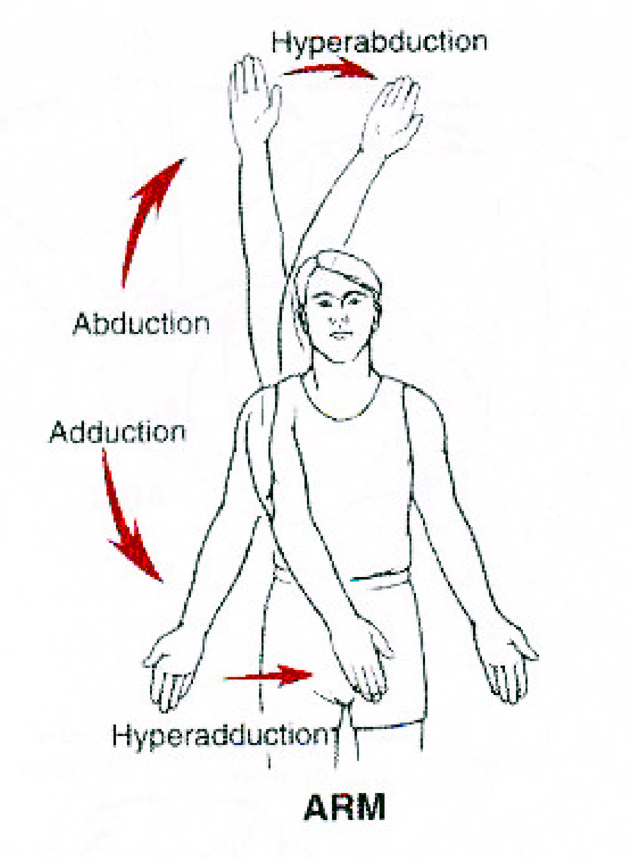

Figure 2.5. Abduction / adduction of the arm
(Source: Hamill and Knutzen, 2003).

2.1.4. Segment rotations

The last two basic movements are segment rotations, a rotation can be either medial (also known as internal) or lateral (also known as external) (Hamill and Knutzen, 2003), as shown in Figure 2.6.

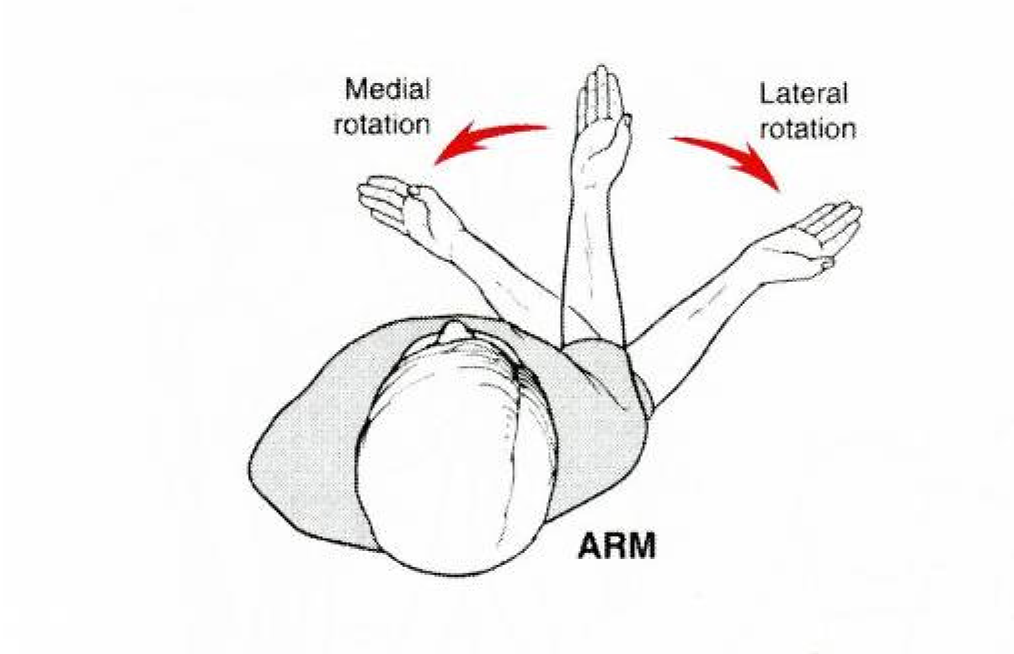

Figure 2.6. Medial rotation/lateral rotation of the arm
(Source: Hamill and Knutzen, 2003).

In the forearm, pronation and supination occur as the distal end of the radius as it rotates over and back on the ulna at the radioulnar joints. As can be seen in Figure 2.7, supination is the movement of the forearm in which the palm rotates to face forward from the fundamental starting position, and pronation is the movement in which the palms face backward. Supination and pronation joint movements have also been referred to as external and internal rotation (Hamill and Knutzen, 2003).

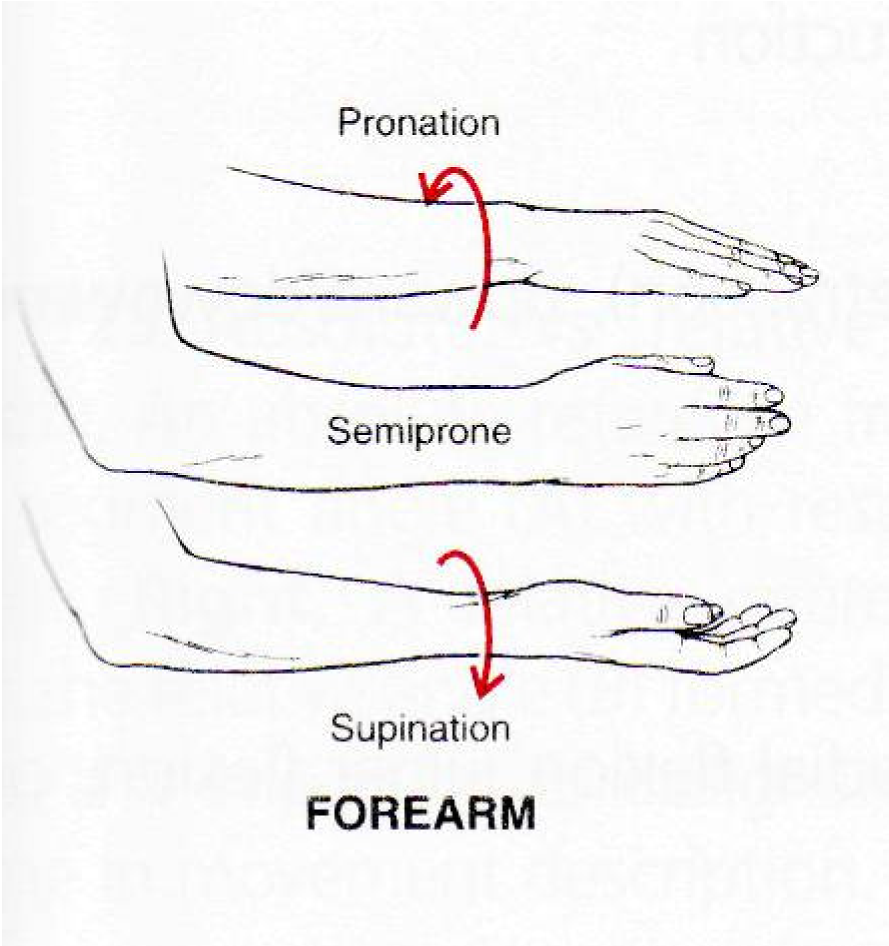

Figure 2.7. Pronation/semiprone/supination of the forearm
(Source: Hamill and Knutzen, 2003).

2.1.5. Upper Limb Disorders

Upper Limb Disorders (ULDs) are common both in the workplace and elsewhere. In 2005/06, an estimated 374,000 people in Great Britain suffered from an ULD caused or made worse by their work (HSE, 2009).

Within MSDs, the term 'work-related ULD' (HSE, 2006) is used as an umbrella for a range of disorders of the hand, wrist, arm, shoulder and neck. It covers those conditions, with specific medical diagnoses (e.g. frozen shoulder, carpal tunnel syndrome), and other conditions where there is pain but no other symptoms. Symptoms may include pain, swelling and difficulty moving. The worst cases can result in permanent disablement if no action is taken. ULD cases can also mean production losses and compensation claims for employers (HSE, 2006).

2.1.6. Work-related Musculoskeletal Disorders (WMSDs)

Musculoskeletal Disorders (MSDs) is a term given to a group of conditions representing a wide range of illnesses that involve the nerves, tendons, muscles and supporting structures such as intervertebral discs (HSE, 2009). They can differ in severity from mild periodic symptoms to severe chronic and debilitating conditions; examples include carpal tunnel syndrome, tenosynovitis, tension neck syndrome and lower-back pain (NIOSH, 2010). Work-Related Musculoskeletal Disorders (WMSDs) are MSDs that are caused or made worse by work methods and the environment (Taiwan IOSH, 2006). They are associated with factors such as work postures and movements, repetitiveness and pace of work, the force of movements, vibration and temperature (CCOSH, 2002).

2.1.7. Training

According to NIOSH (2001), "***Training*** is widely understood as communication directed at a defined population for the purpose of developing skills, modifying behavior, and increasing competence. Generally, training focuses exclusively on what needs to be known. ***Education*** is a longer-term process that incorporates the goals of training and explains why certain information must be known. Education emphasizes the scientific foundation of the material presented. Both training and education induce learning, a process that modifies knowledge and behaviour through teaching and experience."

In general, training refers to instruction and practice for acquiring skills and the knowledge of rules, concepts or attitudes necessary to function effectively in specified task situations (Cohen and Colligan, 1998). It consists of instruction in hazard recognition and control measures, learning safe work practices and the proper use of personal protective equipment, and acquiring knowledge of emergency procedures and preventive actions.

Training in this context, takes several forms with several objectives: (1) the acquisition of basic knowledge about work-related MSDs, risk factors and the core concepts of ergonomics; (2) the development of an ability to understand the work activity as it is carried out, as well as the variability and the determinants (factors); (3) promoting the necessary integration of the viewpoints and knowledge of several people, including participants (workers), the ergonomists and the employees and, finally, (4) the development of multiple solutions and their critical analysis (St-Vincent *et al.*, 2001).

2.1.8. Performance

Performance represents observable actions or behaviours reflecting the knowledge or skill acquired from training to meet a task demand. With regard to occupational health and safety (OH&S), performance can mean signs of complying with safe work practices, using protective equipment as prescribed, demonstrating increased awareness of hazards by reporting unsafe conditions in order to prompt corrective efforts and executing emergency procedures should such events occur (Cohen and Colligan, 1998).

2.1.9. Motivation

Motivation refers to processes or conditions that can energize and direct a person's behaviours in ways intended to gain rewards or satisfy needs. Setting goals for performance coincident with learning objectives and the use of feedback to note progress have motivational value. With regard to OH&S, motivation can mean one's readiness to adopt or exhibit safe behaviours, take precautions or carry out self-protective actions as instructed. Bonuses, prizes or special recognition can act as motivational ***incentives*** or rewards in eliciting as well as reinforcing these behaviours when they are displayed (Cohen and Colligan, 1998).

2.2. Health and Safety Guide for Hairdressing

2.2.1. U.K.

In the U.K., the risk factors causing WMSDs can be found in virtually every workplace from commerce to agriculture, health services and construction. An estimated 11.6 million working days a year are lost to WMSDs (HSE, 2009). Moreover, WMSDs adversely affect worker productivity and cause lost time from work; temporary or permanent disability; the inability to perform job tasks and an increase in workers' compensation costs (NIOSH, 2001).

The Hairdressers Journal International (HJI, 2005) editor presented a new study by the Chartered Society of Physiotherapy stating that nearly half a million workers in the UK have experienced Repetitive Strain Injury (RSI) caused by their working conditions. The HJI editor also mentioned that RSI can be caused by a variety of factors including the fast pace of work, awkward posture and repetitive movement. Symptoms may include tingling, numbness and swellings in the hands, wrists, elbows, shoulders and neck.

2.2.2. U.S.

Cases of musculoskeletal disorders which involved a day away from work were also reported in the Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor statistics (BLS) in the US. It reports that, in 2001, there were 522,528 cases of musculoskeletal disorders that caused an absence from work, 1,582 of these involved hairdressers, hairstylists and cosmetologists, including 575 cases in the upper extremities and 245 cases in the lower extremities out of a total of 329,920 total employees in these service industries in 2001. Working hours spent on Repeated Activities (RA) and the prevalence of low back pain have been found to be a common reason for workers filing compensation claims in the United States and affect large numbers of workers in many other countries (Guo, 2002). An investigation reported by Guo (2002) through the 1988 National Health Interview Survey was analysed and pointed out that female hairdressers and cosmetologists are the third highest major risk occupation of the top 15 for low back pain attributable to their work.

2.2.3. Australia

As can be seen in Figure 2.8 below, the guide published by the State of Queensland, Australia (2009) explains the risk management process that can be used to prevent or minimize risks arising from hazards at hairdressing, nail and beauty workplaces. Working posture, repetition and duration, working area, tools used, load handing, individual factors and work organization are the risk factors to consider in the workplace for Austrian hairdressers in order to manage work-related health and safety.

Manual task risk factors in the hairdressing, nail and beauty industry

Risk Factor	Contribution to Injury	Examples of Work Problems
Working postures	Awkward postures require greater muscular effort and lead to greater fatigue, particularly when holding a position for a long time. Awkward postures occur when joints are working away from the normal position.	• back bent or twisted, e.g.washing hair • neck bent forward or twisted, e.g. applying colour • shoulders raised • upper arms held out to the sides and away from the body, e.g. massage, cutting hair • wrist bent or twisted, e.g. setting rollers, stabilising hand when filing nails
Repetition and duration	Continually repeating a movement, particularly with a forceful exertion increases the risk of injury. Long durations of awkward postures or repetitive work are also a risk.	• rolling hair • filing nails • prolonged sitting or standing • prolonged bending or leaning, e.g. electrolysis. • applying colour
Work area design	The work area design and layout may require workers to bend or reach to perform tasks.	• equipment and materials not located close to the worker causing workers to bend, reach or twist • non-adjustable chairs and benches • work surfaces too high or too low • poor lighting • hard, slippery floors • work surfaces too wide or narrow • leaning or supporting elbows or arms on work surfaces
Use of tools	Poor design and excessive use of hand tools contributes to disorders of the wrist, elbow and shoulder.	• working with heavy tools • difficult or awkward hand grips • vibrating tools eg. electric nail files and drills
Load handling	Supporting a weight while holding arms away from the body increases stress to the back and shoulders.	• working with heavy tools eg. holding a blow dryer away from the body • holding a body part while waxing • carrying heavy boxes of product to storage areas.
Individual factors	For new, young, older, pregnant and inexperienced workers, the risk of injury is increased. The type of clothes people wear can also have an impact.	• lack of training in specific tasks • no period of physical adjustment provided • wearing shoes with an elevated heel
Work organisation	Continuous work of a similar nature, poor equipment maintenance and inadequate rest breaks can result in fatigue and lead to injury.	• too little task variation • inadequate rest breaks • insufficient staff to cope with peak periods

Figure 2.8. Manual task risk factors in the hairdressing, nail and beauty industry in Queensland. (Source from Health and Safety Guide for the Hairdressing, Nail and Beauty Industry, Queensland Government, p.11).

2.2.4. New Zealand

The Department of Labour in New Zealand published a guideline (2007) for health and safety in hairdressing, which mentioned that hairdressers suffering musculoskeletal discomfort, pain or injury experience decreased job performance, lower productivity, increased time off work and possible early retirement from the hairdressing profession. There are ways of changing techniques and practices without stress mentioned in this book (New Zealand, Department of Labour, 2007). Hairdressers, tutors and salons need the courage to embark on changing work techniques and work practices.

It also provides the information for further intervention in this industry:

1. Develop industry "Good Practice" work techniques.
2. Improve understanding and knowledge of the healthy functioning of the musculoskeletal system including:
    a. The delivery of blood to, in and from the muscles,
    b. The movement of fluids in the muscle tissues,
    c. How tendons and joints are lubricated,
    d. The recovery of muscles, tendons and joints.
3. Without understanding and knowledge, better work techniques are less likely to be adopted. It is necessary to have sufficient knowledge to understand the processes and become motivated to adopt good practice.
4. The adoption of micro-pauses, stretching and exercise during the work period.
5. Taking breaks to reduce fatigue and thus reduce the risk of musculoskeletal disorders.

2.2.5. Taiwan

A nationwide study was conducted in Taiwan with a standard questionnaire distributed to a representative sample of 22,475 non-self-employed workers (Guo, 2004). Among the 18,942 (84.3%) who returned the questionnaire, 37% had musculoskeletal disorders. Many cases of MSDs are claiming compensation from labour insurance. Most claims made by hairdressers from 1999 to 2001 in Taiwan were for upper limb disorders (Lin, 2003). Lin (2003) mentioned that the cases of musculoskeletal disorders are increasing every year; however, there is no world-wide scheme of prevention.

2.3. Relationship between job and occupational injuries

2.3.1. Introduction

In the literature concerning the evaluation of risk and performance, although the combination of some independent variables, such as age, gender, work experience and interpersonal effects, has been widely considered in determining task (job) performance, few investigations have indicated the influence of workplace conditions (Kahya, 2007). Kahya (2007) revealed that job performance has a relationship with physical effort, environmental conditions and hazards. In particular with regard to hazards, employees demonstrate that a high level of absenteeism and the need for concentration increases the likelihood of accidents and injuries. Kahya further highlighted that jobs of greater complexity and/or greater autonomy and discretion can be improved by enhancing task performance and contextual performance. In addition, with respect to the limitation of subjective assessment, if the source of the rating is via a supervisor, it would be less reliable because they are affected by factors such as the rater’s instinct, personality and cognitive errors (Podsakoff *et al.*, 1997). Kahya (2007) suggested that alternative objective indicators for some performance measures can be used to support the subjective assessment.

2.3.2. Workplace risk factors associated with a job

Graves *et al.* (2004) reviewed the epidemiological literature that provided good evidence of the associations between workplace risk factors and ULDs, particularly where workers are highly exposed to the following risk factors: These were proceeded by Kahya (2007) as related to:

(1) Job characteristics: some jobs described involve high levels of complexity with job type, job level, physical efforts and job context creating different impacts on job performance. Some jobs require high-level skills and responsibility for tasks to be performed successfully.

(2) Job Analysis: job analysis was undertaken using a questionnaire to obtain current job information for the purpose of determining job characteristics and working conditions, including information about base duties, responsibilities, skills, working conditions and the personal attributes necessary for successful execution.

(3) Job grade: a job grade was designed to evaluate the job. The greater the job score and grade, the higher the level of complexity in terms of job knowledge, responsibility, ability and effort required.

(4) Job performance: it was suggested that task performance could be measured ranging from (1) inadequate to (5) excellent by using the following seven criteria, which are also correlated with the physical effort, environmental conditions and hazards:

- Job knowledge,
- Overcoming obstacles to complete a task,
- Problem solving (ability to solve problems quickly and correctly),
- Operating equipment, using tools, or both,

- Working safely,
- Concentrating on duties,
- Protecting the resources.

(5) Job dedication: it was suggested that dedication to the job also needs to be measured ranging from (1) inadequate to (5) excellent and that this is correlated with the physical effort, environmental conditions and hazards:

- Attention to important details,
- Creativity to solve a work problem,
- Engaging in self-development to improve the individual's own effectiveness,
- Generating new ideas to make things (tasks) better (innovation),
- Planning and organizing work.

(6) Environmental conditions: criteria for vibration and lighting were based on an HSE recommended level. Kahya (2007) suggested that environmental conditions can be assessed via factors including noise, temperature, dust, illumination, dirt and humidity scored from (1) 'never' to (5) 'continuous'. Noise was classified according to three levels: (1) low, (2) 75dBA and below and (3) higher than 75dBA. Temperature had three levels: (1) about 20°C (or cold), (2) 22~30°C, (3) 30°C and above. Furthermore, overall environmental conditions can be evaluated based on levels ranging from 1 "Exposure to environmental conditions is rare", to 5 "Continuous exposure to highly unpleasant environmental conditions".

(7) Working conditions: these imply two dimensions - environmental conditions and hazards - (Kahya, 2007). Environmental conditions range from ordinary to extreme in terms of the environmental risk factors such as heat, humidity, noise, smell, light, and dust. Furthermore, unpleasant environmental conditions have both direct and indirect effects on employee job performance, which might lead to lower employee

performance including productivity, quality and emotional stress, which, in turn, can increase costs. With respect to the hazards, the root causes of workplace health hazards are related to ergonomic deficiencies; however, the application of the relevant human factor principles can reduce the likelihood of accidents and injuries that reduce worker productivity and cause high absenteeism.

2.3.3. Summary

There is a relationship between a job and job-related injuries. In particular, job performance has a relationship with physical effort, environmental conditions and hazards. The job performance refers to the followings elements which involve job knowledge, overcoming obstacles to complete a task, problem solving, operating equipment and using tools, which have strong connections to complex hairdressing techniques and the associated working postures. Thus, it is highly possible that hairdressers who have poor job performance will increase the likelihood of accidents and injuries.

2.4. Techniques

2.4.1. Introduction

Techniques have a strong relation to risk factors, such as repetitions, working postures, force, durations, psychosocial factors, individual differences and interpersonal skills. Most of these factors are related to the job performance and could be assessed and observed as follows:

2.4.2. Repetition

Criteria defining repetitive work are complex with many variations being found in the literature. Highly repetitive tasks have been defined as those with a work cycle time, e.g. less than 30s, or with more than 50% of the cycle time involved in performing the same motion pattern (Silverstein *et al.,* 1986). Kilbom (1994) classified frequencies of more than 2.5 per minute for the shoulder, and more than 10 per minute for the upper arms, elbow, forearm and wrist as high risk. Kilbom also considers work to be repetitive only when undertaken for more than 60 min at a time. Furthermore, Li and Buckle (1999) state that the term ‘frequent’ would be better defined by describing the pattern or manner of the arm movement, rather than by the number of times the arm moved within a given period.

2.4.3. Working posture

Li and Buckle (1999) felt that it was difficult for an observer to assess whether the wrist was beyond 15^{o} or 20^{o} from its neutral position during work. Their questions differentiated posture on the basis of either “almost a straight wrist” or “with a deviated or bent wrist position”. Based on this and similar concerns raised by other ergonomists, Graves *et al.* (2004) suggested avoiding describing postures in terms of specific ranges of movement (i.e. to avoid specifying degrees of flexion/extension, etc.). For neck posture, Graves *et al.* (2004) suggested that two types of question should be used: the first was designed to assess how the task was performed, for instance, does the task involve repetitively bending or twisting the neck? The second assesses whether the visual demands of the task require the workers to view fine details and, by implication, to work with awkward neck postures.

2.4.4. Force (Physical effort)

Graves *et al.* (2004) suggested that the force criteria should refer to Washington Administrative Code (WAC) and Occupational Safety and Health Administration (OSHA). In this study, the RULA is considered. Kahya (2007) suggested that physical effort can be assessed via questionnaire.

2.4.5. Duration

Graves *et al.* (2004) stated that the definition of risk associated with duration poses challenges due to the possible interaction of multiple risk factors when performing work tasks. For instance, a long duration may be acceptable for tasks where other risk factors for injury (such as force, posture, repetition) have minimal influence, whereas a relatively short duration may be unacceptable where the contribution of other risk factors is high. In OSHA's Ergonomic Program Standard, 'more than 2 consecutive hours per workday' was used as a duration value for repetition, force and awkward postures. The Washington Administrative Code (WAC) tended to use 4h as a duration value when dealing with the influence of an individual risk factor such as repetition. Where the WAC included combinations of risk factors, the duration values quoted tended to be less, for instance, with the wrist bent 30^{o} more, the duration was defined as more than 3h in total per workday. It is important to treat these duration values as precise exposure limits.

2.4.6. Psychosocial factors

This will be based on a 'Risk Assessment Worksheet' (Graves *et al.*, 2004).

2.4.7. Individual difference

Graves *et al.* (2004) stated that questions related to individual differences were deemed to be a risk factor, which helps to discourage users from discriminating against various groups.

2.4.8. Interpersonal skill

Kahya (2007) suggested that the interpersonal skills also need to be measured since these are also correlated with the physical effort, environmental conditions and hazards, ranging from (1) 'inadequate' to (5) 'excellent':

- Assisting co-workers with personal matters,
- Cooperating with others to solve problems,
- Engaging responsibly in meetings and group activities.

2.4.9. Summary

Based on the reviewed literature, techniques could refer to the following factors: repetitions, working postures, force, durations, psychosocial factors, individual difference and interpersonal skill. Most of these factors are related to the job performance. Among these factors, criteria defining repetitive work are complex with many variations being found in the literature. Furthermore, the wrist beyond 15^{o} or 20^{o}

from its neutral position could be difficult for an observer to assess during work. As for the definition of risk associated with duration, it poses challenges due to the possible interaction of multiple risk factors when performing work tasks.

2.5. Working posture

2.5.1. Introduction

A few studies have been found concerning risk factors due to working postures in hairdressing industry. An earlier study based on observations made by Tammiene-Peter *et al.* (1985) and his co-workers, showed that tasks that cause strain in the musculoskeletal system of hairdressers are, in increasing severity: rolling, blow-drying, cutting, and washing. They investigated two parlours - an experimental workplace for hairdressers and an ordinary beauty parlour – to find out whether the strain on the musculoskeletal system depended on the workplace. Their results found no difference attributable to the workplace.

2.5.2. Awkward working posture and WMSDs

An awkward working posture has been considered a risk factor related to musculoskeletal disorders in many workplaces, for instance: construction ironwork (Forde and Buchholz, 2004), pipettes (David and Buckle, 1997), mechanical pipettes (Lu *et al.,* 2008), carpet mending operations (Choobineh *et al.*, 2004), driving (Hermanns *et al.,* 2008), water handling (Wu *et al.,* 2009), pub occupations-bartending, waitressing and cooking (Jones *et al.*, 2005), VDT workers at the Hi-Tech company (Shuval and Donchin, 2005) and truck drivers (Massaccesi *et al.*, 2003).

In 1998, Nevala-Puranen *et al.* (1998) carried out research that aimed to increase the participants' physical and psychological abilities and to train them to use work techniques that optimize the load on the musculoskeletal system in their daily work tasks (washing, cutting, rolling, and blow-drying), as shown in Figure 2.9. The result showed that occupationally-oriented rehabilitation had positive effects on hairdressers' daily work techniques, physical capacity and subjective well-being.

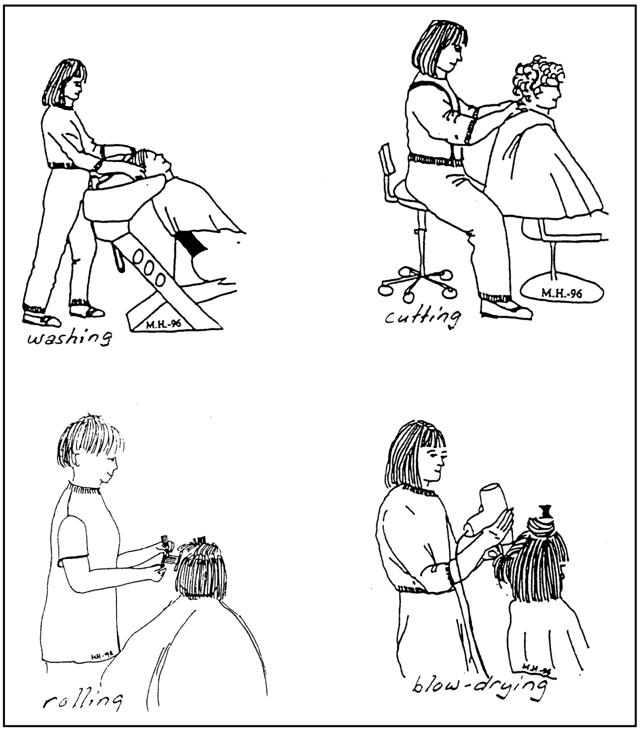

Figure 2.9. Ergonomic work techniques taught for hair washing, cutting, rolling and blow-drying (Nevala-Puranen *et al.* 1998).

Arokoski *et al.* (1998) also examined changes in work techniques and musculoskeletal disorders after occupational-oriented medical rehabilitation of 21 hairdressers who were experiencing neck-shoulder or back pain but were still able to work. This research examined working postures using the OWAS (Ovako Working Posture Analysing System) and used a questionnaire to obtain data for the beginning of the rehabilitation course and for one and a half years thereafter. This study suggested that it is possible that the occupationally-oriented medical rehabilitation can have significant and long-lasting effects on the rehabilitee's work techniques and subjective well-being. In addition, Arokoski *et al*. (1998) pointed out that loading working postures such as repetitive arm movements, elevated arms, and a twisted or bent back are common in hairdressers' daily tasks. Hairdressers generally work standing up and have their back either bent forward or sideways and their arms held up during hair washing. Cutting and blow-drying cause strain in the neck and shoulder area, as well as in the arms.

2.5.3. Summary

An awkward working posture has been considered a risk factor related to musculoskeletal disorders in many workplaces. A few studies have been found concerning risk factors due to working postures in hairdressing industry. An earlier study showed that tasks that cause strain in the musculoskeletal system of hairdressers are, in increasing severity: rolling, blow-drying, cutting, and washing. These working posture and motion can increase the risk of exposure to hazards and continually increase discomfort felt in different body regions.

2.6 Occupational Health and Safety (OH&S) Training Guidelines

2.6.1. Background

In the U.S., more than 100 Occupational Safety and Health Administration (OSHA) standards for hazard control in the workplace contain requirements for training aimed at reducing risk factors for injuries or disease (Cohen and Colligan, 1998). Graves *et al.* (2004) stated that upper limb disorders (ULDs) in the workplace represent a significant cause of ill health in Great Britain.

Training objectives, recognition of job hazards, learning safe work practices and appreciating other preventive measures are expected to contribute to the goal of reducing occupational risk of injury and disease with intervention studies, in particular, being especially supportive (Cohen and Colligan, 1998). Moreover, training can attain objectives such as increased hazard awareness among the workers at risk, knowledge and adoption of safe work practices and other actions that improve workplace safety and health protection.

(1) World Health Organization (WHO)

The WHO (2007) stated that young workers run a higher risk of work injuries arising from lack of experience, limited awareness of existing or potential risks, or immaturity. Working methods, tools and equipment are normally designed for adults and do not take into account the smaller body size of the young, physically immature worker. Thus, children and young people are at a greater risk of fatigue, injury and accidents because of ill-fitting tools and safety equipment. Furthermore, across Europe, 18–24-year-olds are at least 50% more likely to have a non-fatal workplace accident than those in older age groups. It was recommended (WHO, 2007) that efforts should be targeted at the development of methods and instruments, for example surveys or proxy measures, to deal with underreporting and illegal work among children and young people.

(2) U.K.

Graves *et al.* (2004) reported that the Health and Safety Executive (HSE) (2002) provided a systematic framework that could be adopted to develop ULD programmes in a wide range of work settings: “Work-related Upper Limb Disorders: a Guide to Prevention” (*HSG60*). The framework consists of seven stages based on experience gained in developing successful musculoskeletal disorder management programmes in industry:

- Stage 1 – Understand the issues and commit to action.
- Stage 2 - Create the right organizational environment.
- Stage 3 - Assess the risk of ULDs in the workplace.
- Stage 4 - Reduce the risks of ULDs.
- Stage 5 - Educate and inform the workforce.
- Stage 6 – Manage any episodes of ULDs.
- Stage 7 – Carry out regular checks on programme effectiveness.

In order to support the revised guidance (HSE, 2002), the Risk Filter and Risk Assessment Worksheets were developed, which can be used to support stages three and four of this management framework. The tools are targeted at non-specialists who are unlikely to have expert or trained help: the Risk Filter enables non-specialists to determine whether there is a need for a full risk assessment, and the Risk Assessment Worksheet enables a more detailed assessment of risk factors with links to options for controlling the risk of ULDs.

(3) U.S.

In the U.S., there were two research agendas proposed aimed at the prevention of musculoskeletal disorders, one was called the National Occupational Research Agenda (NORA, 2001) unveiled by NIOSH in 1996 and the other one was from the National Research Council and Institute of Medicine (NRC/IOM, 2001) developed by the NORA MSD team. Tables 2.1 and 2.2 provide a summary list of the NORA MSD and NRC/IOM research issues.

Table 2.1. NORA musculoskeletal research agenda (Source: Waters, 2004, page 9).

Surveillance

Surveillance is the ongoing systematic collection, analysis, interpretation, and dissemination of MSD health and hazard information to identify trends, develop prevention strategies, and evaluate the effectiveness of those strategies.
The following are the most significant priorities for surveillance research activities identified by the NORA team:

- Develop user-friendly, standardized workplace surveillance tools for use by both the non-expert and the expert;
- Increase collaboration with federal, state, and non-governmental organizations (insurers, employers, unions, and academics) to encourage comparability of data collection methods;
- Conduct an ongoing national hazard survey targeting physical workplace factors.

Etiologic and medical research agenda

Many risk factors associated with development of musculoskeletal disorders have been identified or suggested. Biomechanical risk factors include exposures to excessive force, awkward posture, movement, and vibration. These can be characterized in terms of their magnitude and temporal factors, such as frequency, repetition, duty cycle, and duration of exposure. Psychological and social factors include work organization arrangements (extended work hours, shift work, piecework, machine pacing), lack of training, inadequate conditioning, and cognitive or emotional stress. Personal factors include variables associated with size, strength, age, gender, cultural factors, and history of injury. Research is needed to better describe the relationship between exposures to these risk factors, both singly and in combination, and the development of disease and disability.
The most significant priorities for etiologic and medical research activities identified by the NORA team are:

- Refine instruments to detect and quantify the contribution of these factors to the disease process;
- More clearly define stages of the MSD process, develop precise diagnostic tools, and provide guidelines for effective treatment and return to work; and
- Clarify the interplay of the factors of different stages of causation, development, and treatment of musculoskeletal disorders and measurement of risk factors.

Intervention research

Research is needed to develop and evaluate new and existing intervention strategies for preventing or reducing the incidence, severity, and disability associated with work-related musculoskeletal disorders. A large amount of research has been conducted over the past few decades, but because of the wide variability between individuals and the complexity of causal and contextual factors and their interactions, there is a need for more research on which interventions are the most effective. Moreover, intervention research is difficult to conduct because adequate comparison controls are often not available and because very large sample sizes are needed to show that an intervention is effective in reducing health outcomes. In many cases, it is not possible to conduct studies aimed at reducing health effects, so studies must rely on demonstrating reduced exposure. Interventions can be tested in the laboratory where confounding factors can be controlled, or tested in the field. Effective control technology should work well in both environments.
The most significant priorities for intervention research activities identified by the NORA team are to evaluate the effects of the following on development and prevention of MSD:

- Alternative (product and/or tool) design criteria (force, spatial requirements of work);
- Optimization of mechanical (force, movement, and posture) work demands and temporal patterns of exposure;
- Manual handling alternatives in posture, movement, force, productivity, and quality;
- Ergonomic training and education;
- Costs and benefits of ergonomics intervention; and
- Job assignment, selection, and choice.

Table 2.2. NRC/IOM research agenda (Source: Waters, 2004, page 10).

Methodological research

1. Develop improved tools for exposure (dose) assessment: Includes developing methods for objectively measuring physical stress in the workplace and developing valid measures of psychosocial exposures.
2. Develop improved measures of outcomes and case definitions for use in epidemiologic and intervention studies: Includes developing tools to identify clinical cases, developing tools and measures to quantify an MSD, further refine standardized survey instruments for epidimiological use, refine physical examination criteria to identify MSDs, refine epidimiologic case definitions, develop classification for nonspecific pain syndromes, refine physiological measures for epidimiological studies, and evaluate definitions of MSDs.
3. In studies of human, further quantify the relationships between exposures and outcomes: Includes dose–response relationships of exposures; evaluating host factors; and interaction of physical and psychosocial factors.

Topic area research

1. Conduct tissue mechanobiology studies: Including animal tissue studies of structural and cellular responses to physical loading; determining whether response to repeated loading is determined by rate, peak, or duration; and identifying sources of pain as related to injury and physical loading.
2. Biomechanics studies: Investigating the role of repetition, workshift and rotation on loading patterns and pain; quantifying the relationship between loading and pain; and exploring psychological stress on musculoskeletal response.
3. Psyschosocial studies: Investigating psychosocial stressors impact on MSDs.
4. Epidemiologic studies: Undertake longitudinal studies of MSDs related to: how MSDs form; physical and psychosocial influences, return to work; rest, recovery, and repair; interventions; and individual factors.
5. Workplace interventions studies: Conduct workplace interventions using: randomized control models; multifactorial interventions; cost-effectiveness; working with industry; and disseminating to targeted industries.

Both research agendas recommended further research on a number of issues, including: (1) development of standardized case definitions for health outcomes, (2) development and validation of partial and consistent methods for quantifying physical and psychosocial exposures and (3) additional human studies to further quantify the relationship between exposures and outcomes.

In particular, workplace interventions are discussed in both agendas: the NORA agenda mentioned that the most significant priorities for intervention research activities are to evaluate the effects of the following on the development and prevention of musculoskeletal disorders:

- Alternative (product and/or tool) design criteria (force, spatial requirements of work);
- Optimization of mechanical (force, movement, and posture) work demands and temporal patterns of exposure;
- Manual handling alternatives in posture, movement, force, productivity and

quality;

- Costs and benefits of ergonomics intervention; and
- Job assignment, selection, and choice.

The NRC/IOM agenda emphasized that intervention studies should pay attention to the further quantification of the relationships between exposures and outcomes, including evaluating host factors and the interaction of physical and psychosocial factors. The NORA agenda tends to emphasise the intervention research on engineering controls, work organization, protective equipment and other intervention issues (e.g. training, regulations, compensation, cost/benefit analysis), which reflects the interests of practitioners. Furthermore, the NRC/IOM agenda recommends that intervention studies be conducted to explore multifactorial interventions, economics, working in the community and dissemination issues (Waters, 2004). Moreover, the NORA agenda indicated that the research process could be improved by strengthening communication between those who conduct research and those responsible for its application. Waters (2004) suggested that research might be more applicable to industry if management and labour reviewed research proposals and had a say in funding and prioritization. In addition, dissemination of research results was needed and many of the dissemination problems could be avoided if there was better communication between the parties involved in the research process, in particular to improve the application of research findings in the workplace. Waters also stated that NORA would serve as a blueprint for building a national research programme by identifying high-priority musculoskeletal disorders research problems. In sum, the proposals and the results of intervention studies need to be disseminated and demonstrated to those who would be interested in applying them for the prevention of musculoskeletal disorders in order to improve the research process.

<u>(4) Taiwan</u>

In Taiwan, with respect to skill standards, the Central Division of the Council of Labour Affairs is in charge of duties related to "skill certification" and "skill competitions", whilst the Bureau of the Employment and Vocational Training (BEVT) and the Council of Labour Affairs are in charge of duties including the overall planning of vocational training, skills certification, job placement services and advancement of employment, management, and evaluation of organizations carrying out vocational training, employment services and skills testing (BEVT, 2007).

In regard to vocational training, BEVT emphasizes strengthening training resources integration, setting up training networks, pushing forward career development and planning pre-employment, job-shifting or a second skill for the unemployed in developing their work skills to return to the job market. In addition, an emphasis is on skills training if accompanied by a living subsidy to secure the livelihood of disadvantaged groups. BEVT also focuses on both research and performance evaluation to carry out planning of employment safety policies and their evaluation systems.

Since 1996, the Department of Health has established a work-related diseases surveillance system. This government-administered system requests practising physicians to report any cases suspected of suffering from work-related disorders. In order to yield an efficient and goal-oriented surveillance system, a network supporting the ongoing programme is needed. Wu *et al.* (1996) reported that the supporting network includes:

- Providing practising physicians with criteria for reporting related information.

- Establishing a referral and feedback system of management and follow-up for cases of the reported work-related diseases.
- Encouraging the factory or family to cooperate when investigating the causes of diseases.
- Providing industrial hygiene control technologies to improve working environments.
- Analyzing these epidemiological data.
- Providing workers with educational programmes to promote occupational health.

2.6.2. Occupational health and safety education

Occupational health and safety education should emphasize the following criteria (van Dijk, 1995):

(1) Target groups should involve employees from shopfloor workers, middle-level employees and high-level managers throughout an organization.

(2) Professional target groups should involve safety experts, occupational physicians, occupational hygienists, work and organization specialists with a background of social sciences and plan for the participation of ergonomists and occupational physiotherapists.

(3) Learn about the need for teamwork during projects where they have to manage a concrete problem in a company collectively.

(4) An important subject of the teaching programme is the training in health and safety at work that should be provided with due attention to the quality of working life: for instance, how to help the company make a risk evaluation, how to promote the purchase of equipment, how to stimulate the more healthy behaviour of employees

and how to support the implementation of a management system to guarantee safe working conditions in the future.

(5) The researchers or consultants have to learn to communicate with their customers more effectively as a way of understanding the problems of their customers, and at the same time not loosing contact with their own mission of health and safety at work.

(6) Education has to be evaluated too. However, it is clear that judgment of the teaching process and of the capacities of the participants is not an easy task, but is cannot be denied that the assessment of the quality is ‘the proof of the pudding’. Therefore, the evaluation methods themselves are subject of evaluation.

To sum up, it is believed that improving task performance and contextual performance can be done by providing training to hairdressers, which could possibly reduce the risk of developing WMSDs.

2.6.3. Training-Learning-Action Model

Hamm (2000) pointed out that the training intervention and effectiveness research (TIER) model can provide a fundamental evaluation model. It employs triangulation (use of multiple data sources and methods) to gather data from prospective end-users and combines qualitative data (e.g., from focus groups, interviews, and observations) with various forms of quantitative data (e.g., those from controlled study situations). Data are then used to assemble a valid argument for the interpretation of results. Hamm (2000) summarised the TIER model as one that looks at training inputs and activities as the independent variables, and their training effects as dependent variables. For instance, outcomes would be to mediate effects, such as satisfaction with the training, or their impacts, such as the application of learned skills.

The TIER model regards five types of study variables as integral to training effectiveness research: independent, dependent, modifying, intervening and confounding variables (see Figure 2.10).

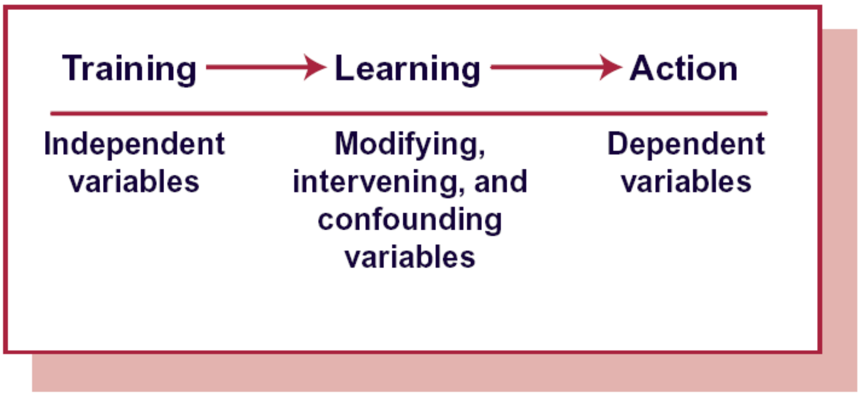

Figure 2.10. Variables influencing the effectiveness of the training-learning-action continuum.

These types of variable include the following (NIOSH, 1999):

(1) Independent variables are the manipulated variables - that is, the training inputs and activities that are implemented and studied. They are presumed to cause or influence certain training outcomes. Depending on the study, independent variables could include timing, format and the location of training as well as modifications to the training rationale, content or educational approach under study.

(2) Dependent variables include sample outcomes of training, including participant satisfaction with the course; changes in knowledge, attitude and behavioural intent along with demonstrated skills or abilities. Sample impacts of training include the following: diffusion of course material into the field, retention of knowledge and attitudes, transfer of behavioural intent into practice, application of learned skills

and abilities, transfer of training to new populations and acceptance of instructional content as normal operating procedures.

(3) Modifying variables can modify the influence of independent variables on dependent variables. Therefore, to preserve the integrity of results, modifying variables must be controlled or neutralized for all study conditions. Learner variables (age, sex, socioeconomic status, etc.), trainer variables (experience, teaching style, etc.) and context variables (class size, classroom instruction versus apprenticeship training, etc.) can all modify learning outcomes. Typically, when modifying variables are suspected, research design techniques, such as stratified sample selection, can be used to control and study their effects on dependent variables.

(4) Intervening variables are inferred concepts intended to explain the processes between stimulus (independent variable) and response (dependent variable). Intervening variables cannot be meaningfully observed, manipulated or measured. In educational research, such constructs frequently relate to learner attentiveness, ability and motivation to learn, learning style and individual coping mechanisms when ingesting new material. Intervening variables may also pertain to (1) the trainer's ability to engage learners with the subject matter and (2) contextual attributes such as the structure and formality of the educational environment. Random selection and assignment of participants are presumed to control for most intervening variables.

(5) Confounding variables are factors beyond the learner's control that can influence training outcomes. These confounding variables act synergistically with the independent variables and thus are suspected of altering the effects on the dependent variables. Therefore, confounding variables can bias the interpretation of data.

Possible confounding variables in effectiveness research are changes in institutional policy, implementation of new technologies and other non-training factors that could influence dependent variables. Again, controls applied to sample selection, research design and data analysis can identify and compensate for the effects of concurrent exposure to multiple causative agents.

The TIER model systematically structures training effectiveness research across four stages (see Figure 2.11). Stages 1 and 2 are components of formative evaluation in which the objectives and processes of training are conceptualized, drafted and refined. During these stages, researchers explore instructional alternatives to determine which are most appropriate for study.

Stages 3 and 4 are components of summative evaluation - a systematic attempt to determine whether the fully-developed training intervention is meeting its objectives as planned or desired.

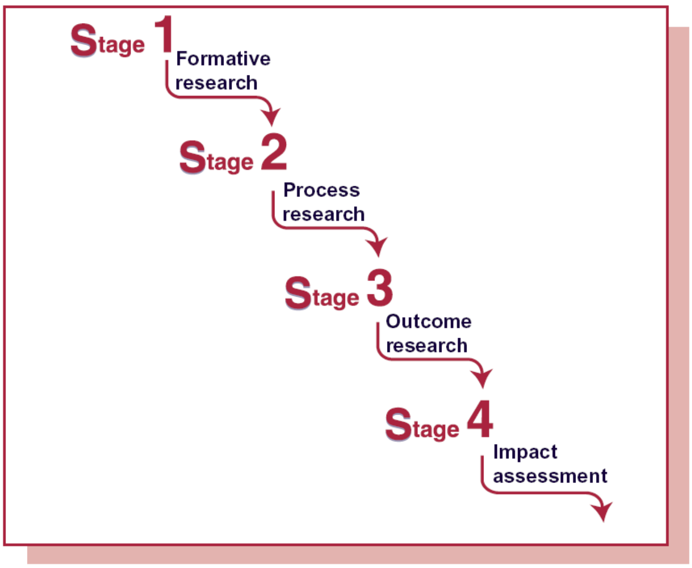

Figure 2.11. Logical and progressive stages for training intervention effectiveness research.

The impact assessment framework recommended by TIER provides a good sample for the assessment of training effectiveness, shown in Figure 2.12. Use of the TIER model will refine and focus the efforts of training evaluation studies. The model will also provide researchers with practical knowledge of training research design and consistency, and with a reliable reference point for launching other investigations.

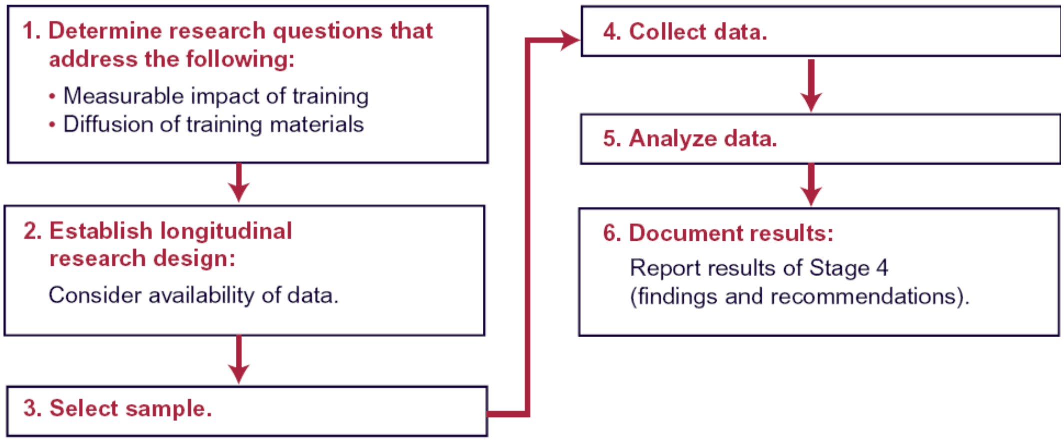

Figure 2.12. Impact Assessment Framework

2.6.4. Intervention training

The use of interventions to prevent musculoskeletal disorders has been studied for many years and has been performed in several different occupations, such as office workers by Robertson *et al.* (2009), the carpet mending industry by Choobineh *et al.* (2004) and the building and construction industry by Albers *et al.* (2005). Choobineh *et al.* (2004) studied the carpet mending industry and found that awkward postures in different parts of the body (i.e. bent neck and back, folded knees) were very common. The Nordic survey revealed that, among the menders, symptoms from knees, back and shoulders over the previous 12 months were significantly more prevalent compared to other body regions. This indicates that any intervention programme for the improvement of working conditions should focus on eliminating awkward postures affecting the mentioned body regions. Most of the menders participating in the second phase of the study found their working postures in the new conditions good and reported them to be comfortable. They believed that the new working conditions were better than the traditional ones. This indicates that the menders felt that the ergonomic intervention improved their working postures.

St-Vincent *et al.* (2001) implemented participatory ergonomics training in the manufacturing sector and ergonomic analysis tools. In order to deal with training problems and learning difficulties, a validated training intervention procedure was provided and useful analysis tools recommended for the different contexts of both short-cycle repetitive tasks and long-cycle varied tasks.

In a participatory context, the first challenge for training people is the relatively short time in which the participant must acquire knowledge and understand basic concepts. In order to overcome this challenge, two key elements for intervention training are emphasized:

1. Development and facilitation of methods and tools that promote the emergence and expression of the participants' knowledge: The methods and tools are interviews and questionnaires, video recording to support the discussion, and the teaching of group work techniques, such as focus groups and brainstorming, used to propose a solution.
2. Identification and improvement of risk factors: They emphasized that participants must be able to develop their intervention from an understanding of the actual work activity through the use of video recordings and the tools mentioned above.

Furthermore, both the evaluation of the risk factors and learning effectiveness must be carried out. With respect to the evaluation of risk factors, some quantification methods might be used, for instance, the sum of the positive responses to the questions in a checklist, weighted according to the exposure risk characteristics (intensity, duration or frequency) (St-Vincent *et al.*, 2001), reported pain and the workers' perceptions. However, the systematic observation process requires observation-specific training (Denis *et al.*, 2008).

In Table 2.3, the validated participatory intervention training process was provided by St-Vincent *et al.* (2001), including the planned steps, the measures proposed (the means) and the people involved.

Table 2.3. Organization of training and evaluation process

(Source: St-Vincent *et al.*, 2001, page 497).

Step	*Means*	*Who*	*Tool 1: Repetitive tasks*	*Tool 2: Varied tasks*
1. Preliminary information	Planning of interviews	Supervisor	Principles dealing with the objectives, planning and conducting of interviews	Same as tool 1
	Interviews	Targeted workers	Questionnaires dealing with: – characteristics of the workers – accidents and symptoms or musculoskeletal pain – identifying the sources of variations in production conditions	Questionnaires dealing with: – same as tool 1 – same as tool 1 – description of operations, their layout, tools, equipment and related difficulties
			Interview summary sheet	Same as tool 1
2. Sampling plan and Observation	Discussion fed by the synthesis of inteviews	Committee Worker and supervisor invited	Principles dealing with the development of the sampling plan and the observation of the work activity	Same as tool 1
	Observation based on plan	Targeted workers	Video recording	Same as tool 1
3. Video analysis	Observation of videos	Committee Worker and supervisor invited	Principles of the breakdown of the cycle into actions and the identification of WMSD risk factors	Typology of problems, principles on the identification of determinants and WMSD risk factors encountered
			Risk factor identification grid	Identification grids for problems and related determinants
4. Prioritization of hazardous activities and identification of determinants	Discussion in order to assign a rating to the actions or operations in the analytical grid and their determinants	Committee Worker and supervisor invited	Criteria for assigning a priority rating to the actions in the analytical grid	Prioritization criteria
				Analysis summary sheet
			Presentation of the main types of determinants encountered	Determinant finding is part of the video analysis step
			Prioritization and determinant-finding summary sheet	
5. Solution-finding	Four-step process: 1. brainstorming 2. development of solution scenarios 3. critical analysis of scenarios 4. detailing of proposed solutions	Committee Worker Supervisor Technical specialists invited	Presentation of the solution-finding process Critical questioning for solution evaluation Summary sheet of the tasks to be carried out for solution-finding	Same as tool 1
6. Solution implementation and follow-up	Four-step process: 1. testing prototypes 2. implementation 3. first adjustments 4. final follow-up	Committee Worker Supervisor Technical specialists invited	Presentation of the steps in solution implementation and follow-up Summary sheet for analysis follow-up	Same as tool 1

Based on their study, an intervention lasted 18 to 24 months, during which time the groups analyzed three or four work situations. The groups met from eight to twelve times to analyze a job in the case of repetitive tasks, and from twelve to fifteen times to analyze a varied task. At the beginning, an introductory course was given which provided the theoretical training, this varied from 14 to 24 hours, and taught the participants about the basics and objectives of ergonomics, the anatomical and physiological concepts related to work and musculoskeletal disorders and explained the main risk factors. It also passed on information about the mandate and role of the members in each group. After that, a sequence of interactive intervention training was given, involving a video recording of a sample of the various tasks being performed and a meeting. The ergonomist attended each group meeting in a supporting role in order to answer the participants' questions and to intervene as needed to fill in any gaps. The expectation was that this ergonomist would intervene less and less, and also document the progress of meetings (i.e. video recording and pen and paper), and then transcribe and record them for the purposes of analysis. In order to obtain qualitative information, each participant might be interviewed in order to identify the degree of participation of each individual and the perceived difficulty of both tasks and the scheme. Thus, a typology of possible difficulties, for instance, tools, equipment, physical layout, material, incidents/contingencies, knowledge/work methods, etc was drawn up (St-Vincent *et al.*, 2001).

The limitations of the participatory ergonomic intervention training (St-Vincent *et al.*, 2001) were the organization's participatory culture; the effect of the cordiality of the work relationships on the effectiveness of training; the length of video recording, which was significantly longer for varied tasks than for repetitive tasks; the difficulty of obtaining permission for employee participation and the increased difficulty that members of the group found when making these recordings. Furthermore, the intervention training required a relatively long follow-up: In the case of St-Vincent *et al.* (2001), two years were taken to attend all the meetings during the intervention training process. In fact, it is clear that the interventions also reflected the ergonomists' reaction to how these meeting were progressing, therefore the ergonomists' interventions were modulated by at least three factors: what was felt to be important, what was thought to be a deficiency and by the experience with participatory groups. For instance, very experienced ergonomists, in both job analysis and interaction with the participants' groups, undoubtedly facilitated the process.

2.6.5. Summary

It is believed that jobs of greater complexity and/or greater autonomy and discretion can be improved by reducing or improving task performance and contextual performance. Providing training to hairdressers could be a possible way to reduce the risk of, or to prevent, WMSDs.

2.7. Conclusion

An awkward working posture has been considered a risk factor related to musculoskeletal disorders in many workplaces. A few studies have been found concerning risk factors due to working postures in hairdressing industry.

An earlier study showed that tasks that cause strain in the musculoskeletal system of hairdressers are, in increasing severity: rolling, blow-drying, cutting, and washing. These working posture and motion can increase the risk of exposure to hazards and continually increase discomfort felt in different body regions. As regards, hairdressers suffer musculoskeletal discomfort, injury and harm, which means not only decreased job performance and lower productivity, but also increased time off work and early retirement from this profession.

There are various forms of discomfort felt in body regions, however, as hairdressers work in different ways and use different techniques, how to decrease this discomfort whilst at the same time identifying the most important points to improve their techniques of posture and movement without detriment to the look of hairstyle is an important problem. From this point of view, the strategy for reducing risk and for the evaluation of training effectiveness will make a contribution to this industry.

To sum up, there is an urgent need to validate the exposure of the risk factor for the implementation of the risk prevention in hairdressing working postures. It is hoped that the goal of this research will not only turn the theory of assessment exposure in hairdressing techniques into suitable assessment methods, but will also explain the causes of discomfort to those hairdressers who have little knowledge of ergonomics.

Chapter Three: Methodology

3.1. Introduction

This research aims to provide a validated, ergonomics training programme which could benefit the trainee hairdressers in the educational system in Taiwan. The research emphasized that ergonomics should form part of the education of hairdressers since it is clear that there is a relationship between working postures and WMSDs in various body regions. The triangulation between working postures, techniques, discomfort and intervention (i.e. which can be referred to as job performance) is illustrated in Figure 3.1:

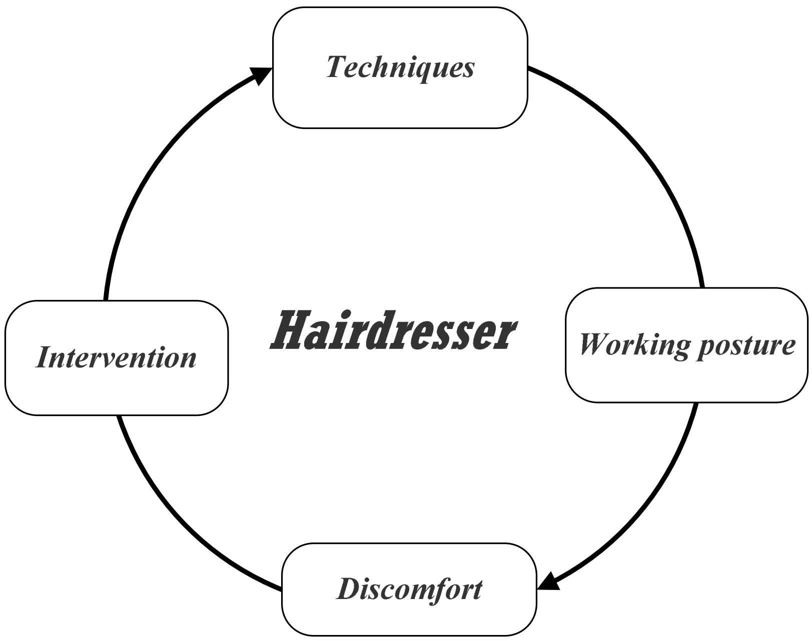

Figure 3.1. Triangulation between postures, techniques, discomfort and intervention.

As regards, techniques could refer to the following factors: repetitions, working postures, force, durations, psychosocial factors, individual differences and interpersonal skill. Most of these factors are related to the job performance. The poor posture and body motion might lead to local mechanical stress on the muscles, ligaments and joints, resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system. In turn, this could generate discomfort in particular body regions cumulatively. In order to reduce the discomfort, the ergonomics training programme needs to be taught to educate hairdressers about the relationship between the job, the techniques, the job description and the working posture.

Based on the literature review, the TIER model (NIOSH, 1999, Hamm, 2000) is considered to be the foundation of the methodology used in this research for validation of the triangulation since it has the following advantages:

(1) It provides a sequence of investigations into the status of WMSDs for hairdressing in Taiwan;

(2) It is a training effectiveness evaluation process for a WMSDs prevention framework as the strategic solution that secures a continuous improvement in the awkward working postures adopted during the functional activities of the various daily hairdressing techniques.

In this research, a modified TIER model is proposed, as shown in Figure 3.1. Use of the TIER model will refine and focus the training-evaluation studies.

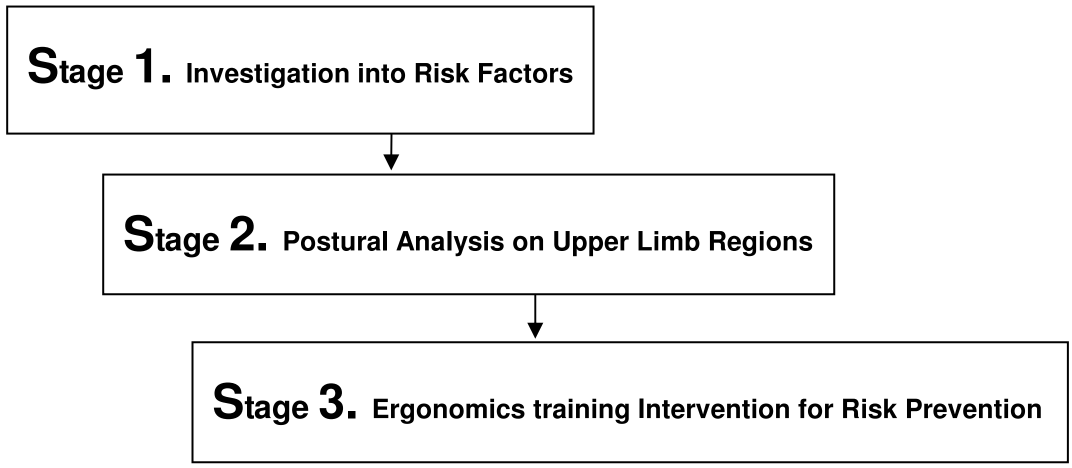

Figure 3.2. Modified TIER model used in this research.

The model will provide researchers with practical knowledge of training research design and consistency and with a reliable reference point for launching other investigations. The modified TIER model systematically structures training effectiveness research across three stages, described as follows:

1. Stage 1 is the component of the formative evaluation in which the objectives and processes of training are conceptualized, drafted and refined. Since the risk factors associated with discomfort in the various body regions are unknown, a hairdresser-oriented questionnaire is employed to discover a wider range of the risk factors for WMSDs among Taiwanese hairdressers. It helps to identify and refine the most appropriate factors for following-up study. In this questionnaire survey, the independent variables are risk factors (i.e. age, work experience, working hours, body regions of the upper limbs and hairdressing techniques, etc.), and the dependent variable is the discomfort felt in the regions of the upper body and limbs.

2. Stage 2 is the component of the formative evaluation in which the objectives and processes of training are refined. Hairdressing techniques identified by stage 1 as having most discomfort will be further evaluated using the observation method to identify critical hairdressing techniques (i.e. the independent variable) having awkward working postures (i.e. the dependent variable) in order to secure further improvement of the related awkward working postures in the following stage.
3. Stage 3 is a component of the summative evaluation - a systematic attempt to determine whether the fully-developed training intervention is meeting its objectives as planned or desired. In this research, the top critical hairdressing working postures identified by the investigation will be improved by the implementation of an ergonomics training programme. Therefore, by comparing the difference between the pre-test and post-test for the upper extremity motion selected, it is hoped to validate the effectiveness of the proposed programme (i.e. the independent variable) for the reduction of the risky joint angles (i.e. the dependent variable) of the professional hairdressers to approach the neutral posture.

The methods associated with the modified TIER model are summarised as follows, with a brief discussion of their reliability and validity.

3.2. Stage 1: Investigation of the Risk Factors

3.2.1. Introduction

Wu *et al.* (2004) emphasised that hairdressers take a long time to provide their services for hair-washing, drying, or even dyeing and perming. During the whole process, they also have to bend, raise their hands whilst standing continuously. Moreover, it always takes several years to make a hair salon assistant into a hairstylist. As a result, the long-term overuse of limbs may cause musculoskeletal disorders.

The Nordic Musculoskeletal Questionnaire (NMQ) has been applied in various jobs, as the scales in the questionnaire are very reliable. In Taiwan, Wu *et al.* (2004) conducted a questionnaire survey based on the amended NMQ method with 36 hairdressers from thirteen hair salons as part of a study of the musculoskeletal disorders in employees working in beauty salons in Kaohsiung, Taiwan. Wu revealed that most of the discomfort comes from the shoulders (94.4%), lower back (80.6%) and neck (77.8%). Moreover, a similar result from a quantitative study (n=360) by Chuang (2005), found that 94.4% of hairdressers voted that their shoulders were the most uncomfortable body region, followed by the lower back and neck. In short, it is obvious that most research into WMSDs indicates that hairdressers suffer from discomfort in their upper limbs, neck, shoulders, lower back and wrists. Therefore, the questionnaire design is based on amending the NMQ to investigate the risk factors for WMSDs within the hairdressing industry by identifying the body regions which exhibit significant discomfort.

3.2.2. Validity and reliability

Regarding the validity and the reliability of the questionnaire survey, the NMQ has been widely adopted by the many previous researchers mentioned earlier, thus it has comparative validity, i.e. the outcome of the research can be compared with the previous studies. Furthermore, the reliability of the questionnaire survey will be examined based on an inter-reliability test (e.g. Cronbach's alpha).

3.3. Stage 2: Postural Analysis on Upper Limb Regions

3.3.1. Introduction

Observation methods have frequently been used to estimate work postures and work movements in the study of work-related musculoskeletal disorders (Juul-Kristensen *et al.*, 2001). Observations have been reported to combine a relatively low cost with large capacity, versatility and generality and an acceptable precision (Winkel and Mathiassen, 1992). At the workplace, where interference with the task has to be minimized and where different postures have to be observed over long periods of time, video-recording has many benefits (Vedder, 1998).

In general, video recording is frequently used as the basis for posture analysis and has been applied in various risk factors exposure assessment methods, such as the following:

- ***Ovako Work Posture Analysis System (OWAS) observation method:*** The OWAS method as a practical method was started in 1973 by Ovako Oy, which is a private company producing steel bar, wire rod and pig iron (Karhu,1977). This method has been widely used in a number of industries, such as by Hignett (1996) to analyse musculoskeletal injuries among nurses and in the building construction industry for cement workers (Kivi,1991).
- ***Rapid Upper Limb Assessment (RULA):*** this survey method was developed by McAtamney and Corlett (1993) for use in ergonomics investigations of workplaces where work-related upper limb disorders were likely. RULA allowed the evaluation of the postures adopted, forces required and muscle actions of both VDU operators and operators working in a variety of manufacturing tasks where risk factors associated with upper limb disorders may be present (McAtamney and

Corlett, 1993).

- ***Rapid Entire Body Assessment (REBA):*** A team of ergonomists, physiotherapists, occupational therapists and nurses collected and individually coded over 600 postural examples to produce a new tool incorporating dynamic and static postural loading factors, a human-load interface (coupling) and a new concept of gravity-assisted, upper-limb positioning (Hignett and McAtamney, 2000).
- ***Risk assessment worksheet:*** The aim of the Risk Filter is to set out an approximate threshold below which the risk of Upper Limb Disorders (ULDs) is likely to be low (HSE, 2006). The guidelines, risk filter and worksheets are provided as an aid to risk assessment.

3.3.2. Rapid Upper Limb Assessment (RULA)

There are many assessment tools to expose the risk factors for musculoskeletal disorders, however, RULA and REBA are still being applied in many industries and presented in papers worldwide. RULA, as introduced in the paragraph above, is a tool that allows the evaluation of the loads due to work posture, muscles used and force exerted and the calculation of the exposure to the risk factors associated with work-related upper limb disorders. RULA is also a validated tool that assesses biomechanical and postural loading on the upper limbs. According to this method, a score is calculated for the posture of each body part, which is divided into sections according to criteria. As explained by McAtamney and Corlett, these sections are numbered so that the number 1 is given to the range of movement or working posture where the risk factors present are minimal.

In order to evaluate the risk level of these hairdressers experiencing WMSDs with, this study employs the RULA online scoring system to gather the overall score for the selected working postures of the four hairdressing techniques. Generally speaking, the RULA method consists of the following three steps:

(1) Observing and selecting the posture (s) to assess

Step 1 aims to identify the techniques that are representative of the extreme joint angles of a working posture. Depending upon the type of study, selection may be made of the longest-held posture or what appears to be the ‘worst’ posture(s) adopted. The static photos of these selected working postures and associated job descriptions need to be summarised in a table before the next step.

(2) Scoring the posture using the web-based RULA tool

Step 2 aims to score the postures using the web-based RULA tool (source: http://www.rula.co.uk/). These representative photos illustrate the working posture of the upper limb, thus the RULA analysis result includes both the right and left limb.

(3) Acton Level Analysis

Step 3 aims to obtain the action level for further action. The overall score can be generated by the on-line tool and compared to the Action Level List, having four risk action levels that require an improvement of the working posture when carrying out the associated hairdressing techniques, shown as follows:

Action level 1: An overall score of 1or 2 indicates that the posture is acceptable if it is not maintained or repeated for long periods.

Action level 2: An overall score of 3or 4 indicates that further investigation is needed and changes may be required.

Action level 3: An overall score of 5 or 6 indicates that investigation and changes are required soon.

Action level 4: An overall score of 7 or more indicates that investigation and changes are required immediately.

3.3.3. Validity and reliability

Regarding the reliability and validity of the postural analysis, since 1993, Rapid Upper Limb Assessment (RULA) has been a validated tool that assesses biomechanical and postural loading on the upper limbs. According to this method, a score is calculated for the posture of each body part, which is divided into sections according to criteria. These sections are numbered so that the number 1 is given to the range of movement or working posture where the risk factors present are minimal as explained by McAtamney and Corlett (1993).

However, direct measures are often associated with high cost, time consumption, subject interference and being difficult to perform for large sample sizes (Li and Buckle, 1999). The analysis of high-risk working postures is very subjective in terms of the individual differences that rely on data analysis based on the well-defined duration and repetition of particular high-risk working postures. Therefore, for the experiment, a standard operation procedure (SOP) will be used as a checklist to ensure the reliability of the observations and the related analysis.

Nevertheless, qualitative observations have been needed to support the findings of the quantitative method using the questionnaire survey in stage 1, which helps to gain internal validity. As a part of the systematic evaluation procedure for the ergonomics intervention training, the risky hairdressing techniques identified in stage 1 tend to involve risky working postures identified in stage 2.

3.4. Stage 3: Ergonomics Training Intervention for Risk Prevention

3.4.1. Introduction

The body movement can be measured by three-dimensional (3D) imaging techniques. In 1998, He and Tian (1998) pointed out that the automatic tracking of motion data recorded via a digital camera had facilitated the study of human movement. In 2007, Petuskey *et al.* (2007) stated that 3D imaging techniques allow the clinician and ergonomists to measure the position of the extremity in space during the performance of a simulated functional task. 3D imaging techniques also provide a way to document the multi-planar functional limitations in the upper extremity. They suggested that 3D imaging techniques are a good basis for the statistical comparison of normal and abnormal participants, or for measuring outcomes during training interventions and treatment. Our observations using 3D imaging techniques show that these parameters are easy to detect and are a clinically useful measure for the statistical comparison of populations.

3.4.2. Using 3D motion analysis to explore the relationship between technique and motion

Carey *et al.* (2008) emphasized that data obtained from 3D imaging techniques can lead to the development of a kinematic model for a transradial prosthesis or as a training guide for upper limb prosthetic use during activities associated with various working tasks. These techniques have not been routinely used for this purpose primarily due to a lack of standardized protocols stemming from the complex nature of UE motion (Barker, 1996).

Furthermore, 3D motion analysis offers the opportunity to reveal the relationship between extremity motion and the risk of experiencing work-related injuries. In 2006, Faupin *et al.* (2006) studied the relation between a range of upper extremity motions and the key risk factors for joint pain, as in hand bike propulsion, with the help of 3D movement analysis. They revealed that the high amplitudes and fast angular joint accelerations of the upper extremity could result in overuse injuries.

3.4.3. Validity and reliability

Regarding the reliability and validity of the 3D motion technique, the objective data collected by the motion capture system can accurately represented the joint angles on a real-time basis in three dimensions. For instance, the data collected had an accuracy on a calibration of 1/1M° of angle in this research. It can be validated by using the 3D skeleton animation software on which the data can be played back to further explain the body movement. During the tests, the adoption of a standard operation procedure (SOP) will reduce the process bias for all participants. The task cycle duration analysis will be used for the validity study to see whether risky hairdressing techniques have risky working postures.

However, He and Tian (1998) indicate that a problem with the use of 3D imaging techniques was the outliers in the recorded camera data arising from tracking errors. These include missing markers and switched positions of the different markers in the tracked data and a block of data points in the trajectory jumping back and forth between two values caused by discrepancies between the two lenses of the same camera. Lu and O'Connor (1999) reported that spatial reconstruction of the musculoskeletal system and calculation of its kinematics using a marker-based multi-link model are subject to marker skin movement artefacts. Thus, He and Tian (1998) suggested that the human operator’s judgment is still required in such cases and that the ultimate solution for removing outliers is to use more cameras and to improve tracking technology such that each marker can be uniquely and accurately tracked, eliminating the error at its source. Fortunately, current developments in motion systems have provided a filtering algorithm which statistically smoothes the characteristics of the camera data under the assumption that a human movement trajectory should not contain any sudden shifts.

3.5 Ethical concerns

Regarding ethical concerns, the Human Research Ethics Committee HREC in De Montfort University has approved that this research will concentrate on the study of work injuries and their ergonomics assessment, which will counter potential crises arising from job injuries among hairdressers in their workplace. Please see Appendix G for a copy of the approved HREC.

Chapter Four: Investigation into Risk Factors

4.1. Introduction

Since a hairdresser typically spends long working hours on various daily tasks, such as cutting, blow-drying, perming and washing hair, work-related musculoskeletal disorders are likely to be caused which impact on particular regions of their body (Fang *et al.,* 2007). In fact, hairdressers' exposure to work-related musculoskeletal disorders are, to our knowledge, insufficiently described in the literature, and knowledge regarding musculoskeletal disorders in this group is also sparse (Veiersted *et al.*, 2008). Leino *et al.* (1999) mentioned that chemical and ergonomic work factors cause significant discomfort and even work-related diseases for the workers in the salons.

According to the data from Taiwan's Bureau of Labour Statistics (DGBAS, 2010), approximately 30,000 workers were employed in salons or barbershops in Taiwan. The Institute of Health and Safety began developing a work injury prevention strategy and health and safety standards for the Government, employers and employees in 2002 (Lin, 2003). Lin also pointed out that cases of WMSDs claiming compensation from labour insurance between 1999 and 2001 showed the highest levels of compensation being granted to Taiwanese workers in the hairdressing and barber industry for upper limb disorders. Although the total number of hairstylists is limited compared to other industry populations, the hairdressing industry accounted for 24% of all compensation cases for work-related, hand-wrist morbidity between Jan 2003 and June 2006 (Taiwan IOSH, 2006).

WMSDs have been a worldwide issue in many countries. Amongst these, English *et al.* (1995) studied five hundred and eighty cases; the diagnoses of the cases included soft tissue conditions affecting the shoulder, elbow, forearm, wrist, thumb, hand, and fingers; the controls included traumatic, degenerative, and inflammatory conditions, mostly of the legs and lower back. The highest risk found for shoulder cases was amongst female hairdressers. In 1988, an investigation reported through the National Health Interview Survey was analysed by Guo (2002), who pointed out that female hairdressers and cosmetologists are the third highest risk group of the top 15 major occupations for lower back pain attributable to repeated activities at work.

One of the common assessment methods used for investigating the prevalence of work-related musculoskeletal disorders in a particular occupational status is the Nordic Musculoskeletal Questionnaire (NMQ), presented by Kuorinka (1987). This questionnaire intended to help define the problem and its relationship to work factors. Thus, this study will use a modified NMQ to investigate the risk factors of Taiwanese hairdressers' work-related musculoskeletal disorders.

4.2. Aim and Objectives

This study aimed to discover a wider range of the risk factors for WMSDs among a large number of Taiwanese hairdressers (targeting 200 hairdressers) by means of a national, modified, hairdresser-orientated, musculoskeletal questionnaire survey relating hairdressing techniques and levels of discomfort in various body regions. Firstly, a pilot study for the initial risk factor exploration and the evaluation of the reliability of the questionnaire design was launched. In order to do so, the objectives were:

- To review the relevant literature;
- To develop a hairdresser-oriented musculoskeletal questionnaire;
- To conduct a pilot study with twelve Taiwanese hairdressers through the use of

the questionnaire designed and discuss the inter-reliability of this design. The findings have been published at the IASDR conference in 2007 (Fang *et al.*, 2007);

- To review the comments following the conference paper from IASDR 2007 (Fang *et al.*, 2007) and modify the hairdresser-orientated musculoskeletal questionnaire used in the pilot study;
- To select participants from twenty-six different hair salons (targeting 200 hairdressers in Taiwan) through the use of the modified questionnaire;
- To collect and analyze the results to identify levels of musculoskeletal discomfort and associated risk factors.

4.3. Pilot Study

4.3.1. Participant selection criteria

Twelve professional Taiwanese hairdressers from two hair salons, volunteered to join this pilot for the use of the musculoskeletal questionnaire. All participants met the following selection criteria:

- They were over 18 years old.
- They had over one-year's work experience as a full-time hairdresser.

4.3.2. Questionnaire design

Based on the reviewed literature, the questionnaire survey shown in Appendix A "Hairdresser's Musculoskeletal Questionnaire (Chinese Version I)" and Appendix B "Hairdresser's Musculoskeletal Questionnaire (English Version I)" was conducted. The musculoskeletal disorders among hairdressers were approached through three main groups of questions, shown as follows:

- Background information regarding independent variables, i.e. age, gender;

- Working conditions related to risk factors, i.e. work experience, working hours, break-taking, symptoms of discomfort, level of discomfort, etc. In this case, a five-point Likert scale is employed to measure the subjective feeling about the level of discomfort for twelve body regions, i.e. the higher the score, the higher the level of discomfort.
- Effects and causes of discomfort.

4.3.3. Selected analysis and discussion

All statistical calculations were performed using the Statistical Packages for the Social Sciences (SPSS) software version 13 (Chen, 2004).

(1) Inter-reliability test

The hairdresser-oriented musculoskeletal questionnaire approach indicates a very high level of reliability on a five-point scale of discomfort for twelve body regions (Cronbach's alpha = 0.95). Therefore, the results collected, based on a step-by-step confirmation approach, are reliable.

(2) Level of discomfort in body regions

As can be seen in Figure 4.1, 91.7% of participants reported shoulder discomfort, followed by lower back (83%) and neck (75%). This result validates the level of discomfort among body regions as being the same as in previous research by Wu *et al.* (2004) and Chuang (2005). Moreover, 33.4% reported a 'mild-to-moderate' level of shoulder discomfort, followed by neck (25%) and lower back (25%). Therefore, among hairdressers, the shoulder region is the most likely to suffer bodily discomfort.

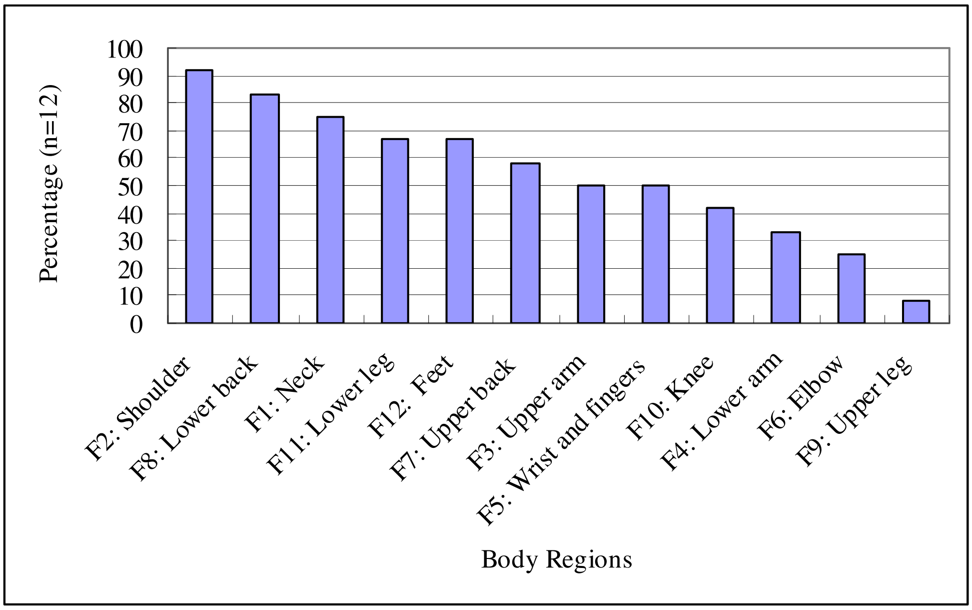

Figure 4.1. Percentage of the participants who reported discomfort in specific body regions (n=12)

4.3.4. Discussion

The hairdresser-oriented musculoskeletal questionnaire in this study is considered to be reliable and valid from the analysis. The study shows that the majority of participants report arthritic pain in the neck, shoulders and lower back, with the body regions showing greatest discomfort being the shoulder, lower back and neck.

The result has been published in the International Association of Societies of Design Research (IASDR) (Fang *et al.*, 2007). The comments from the commentary on the conference paper from IASDR 2007 (Fang *et al.*, 2007) suggest that since the questionnaire design has no illustration of left and right limbs, it might be difficult to read for those with little expertise in the area of ergonomics. This study further indicates that any interventional programme for working conditions improvement should focus on eliminating risky postures of the mentioned body regions within hairdressing techniques.

4.4. Trial Protocol

4.4.1. Participant selection criteria

In total, two hundred and twenty professional hairdressers were randomly selected from twenty-six different hair salons, categorised into six different hair-salon companies in Taiwan. As with the pilot study, all participants had be meet the following selection criteria:

- Be over 18 years old.
- Have over one-year's work experience as a hairdresser.

4.4.2. Questionnaire design

Following the previous study (Fang *et al.*, 2007), a modified version of the musculoskeletal questionnaire was used to measure the prevalence of work-related musculoskeletal disorders among hairdressers against hairdressing techniques. The questionnaire included demographic questions, personal information (i.e. gender, age), working conditions (i.e. hair salons, job position, work experience, working hours per week, working hours spent standing and the trouble due to work-related musculoskeletal disorders), hairdressing technique used and self-awareness of hairdressing-related musculoskeletal discomfort.

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Categorical questions were used to address the overall discomfort of ten body regions in the upper limbs (e.g. neck, right/left upper arms, right/left forearms, right/left hands and fingers, etc.) and lower back during the whole career lifespan, and the discomfort level associated with five main hairdressing activities (hair-washing, hair-cutting, hair-perming, hair-colouring and hair-blow-drying). At the end, the questionnaire explored problems associated with WMSDs during the whole career lifespan, the questions include the following: Is there any connection between hairdressing career and WMSDs? Have any accidents occurred due to WMSDs? Have you taken any sickness leave due to WMSDs?

Based on previous questionnaire design and associated suggestions, the second version of hairdresser's musculoskeletal questionnaire was conducted, shown in Appendix C "Hairdresser's Musculoskeletal Questionnaire (Chinese Version II)" and Appendix D "Hairdresser's Musculoskeletal Questionnaire (English Version II)". The musculoskeletal disorders among hairdressers were approached through four main groups of questions, shown as follows:

- Background information regarding independent variables, i.e. age, gender.
- Working conditions related to risk factors, i.e. work experience, working hours,

break-taking, symptoms of discomfort, level of discomfort, etc.

- Self-awareness associated with hairdressing-technique-related discomfort in body regions.
- Effects and causes of discomfort.

As recommended from the pilot study, an illustration of left and right limbs was provided in order to enhance the readability of the questionnaire. Therefore, a picture was provided, showing the body regions of the upper limb with a five-point Likert scale classified using the following emoticons , as shown in Figure 4.2. In this case, the icon represents the score 1 relative to the lowest level of discomfort in the specific body region, and the icon represents the score 5 relative to the highest level of discomfort in the specific body region.

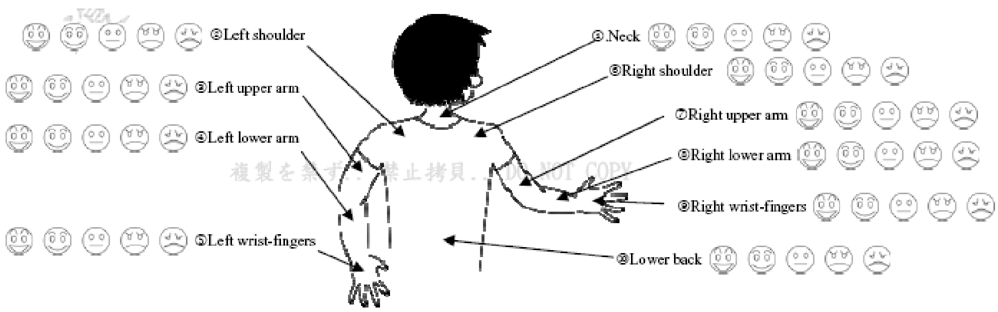

Figure 4.2. A picture showing the proper location of ten body regions.

4.4.3. Standard Operation Procedure (SOP)

A standard operation procedure (SOP), shown in Figure 4.3, was used as a checklist to ensure the reliability of the questionnaire survey. There were five sections in the experiment. In section 1, the questionnaire form was conducted based on the NMQ criteria and a step-by-step confirmation approach was adopted to increase reliability.

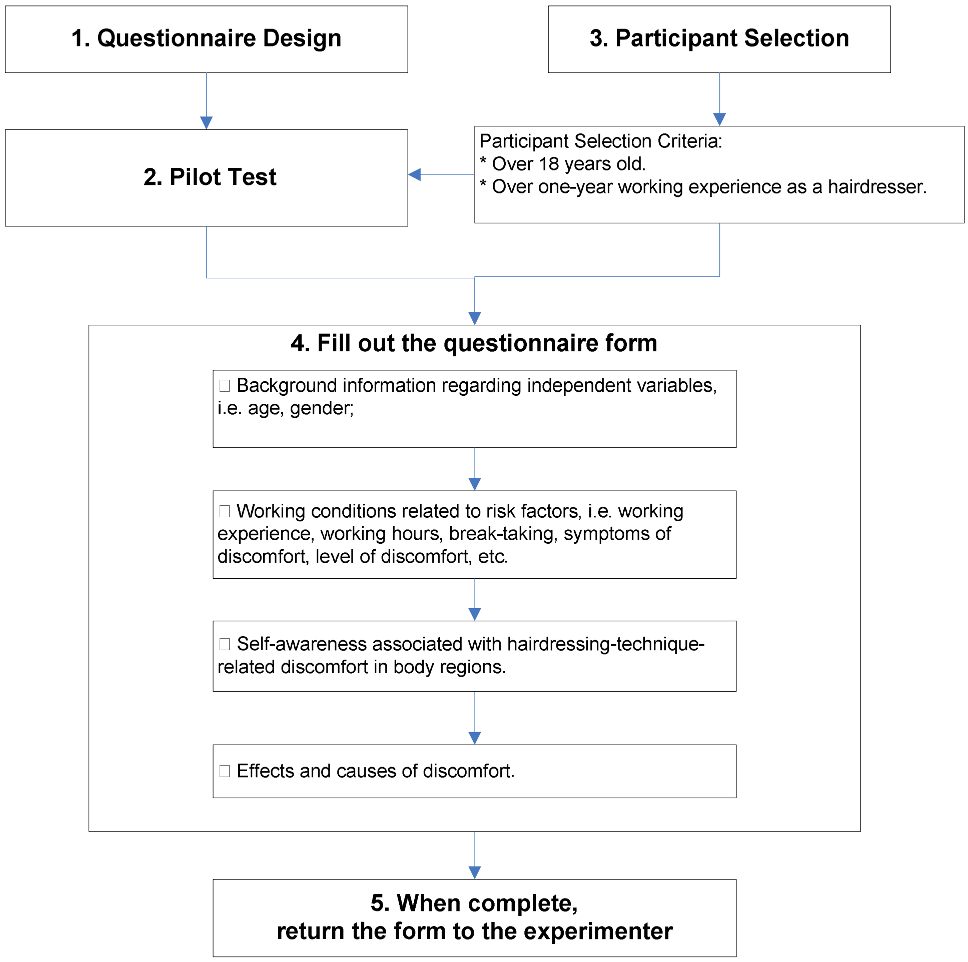

Figure 4.3. Standard operation procedure (SOP).

In section 2, a pilot was conducted to examine the internal reliability of this modified questionnaire design with thirty-three hairdressers randomly selected from the SHOW LIN headquarters in Taipei, Taiwan. Note that SHOW LIN branches are one of the top hair salons in Taiwan. As a result, the scale of discomfort in body regions of each task and for the discomfort in performing each sub-task obtained very high inter-reliability, Cronbach's alpha > 0.927 and 0.89. Therefore, there was no need for a revision of the questionnaire design.

In section 3, in order to maximize the response rate, two hundred and twenty professional hairdressers from twenty-six hair salons, including the SHOW LIN branches, Happy Hair branches, Touch Hair branches and Double La Mode hair salon, who met the selection criteria, were randomly selected to join this study. These branches are the most famous hair salons in Taiwan.

In section 4, two hundred and twenty questionnaires were delivered to hair salons and were later collected by the researcher.

In section 5, participants returned the form to the researcher when complete. In total, two hundred and twenty filled-out questionnaires were collected, a response rate of 100%.

4.5 Analysis

4.5.1. Data and statistical analysis

All categorical answers were entered into an EXCEL™ database and encoded with numeric values. Means and standard deviations (S.D.) were used to describe the demographic details such as age, work experience, working hours per week and working hours spent standing. Frequencies were tabulated, and charts plotted to report the discomfort level and problems due to WMSDs.

The Pearson $\chi 2$ test was performed on all categorical variables shown in Table 4.1, to determine if any significant differences existed (Witter and Witte, 1999). All statistical calculations were performed using SPSS version 13 software (Chen, 2004). Differences were regarded as significant when a *p value* of < 0.05 was attained.

Categorical variables (n=220).

Categorical Variables	Category	Distribution
Age (yr)	>=10 ~ <20	78 (36)
	>=20 ~ <30	109 (50)
	>=30 ~ <40	28 (12)
	>=40 ~ <50	5 (2)
Gender	Male	45 (21)
	Female	175 (79)
Work experience (months)	>=0 ~ <60	124 (56.4)
	>=60 ~ <180	50 (22.7)
	>=180 ~ <240	46 (21)
Working days per week (day/wk)	5	15 (7)
	6	179 (81)
	7	26 (12)
Working hours per day (hr/day)	<=11	41 (19)
	11	71 (32)
	>11	108 (49)
Working hours per day spent standing (hr/day)	>=0 ~ <5	5 (2.3)
	>=5 ~ <10	8 (3.6)
	>=10~ <15	207 (94.1)

4.5.2. Inter-reliability

The hairdressers musculoskeletal questionnaire approach has represented a very high level of reliability on a five-point Likert scale of discomfort for ten body regions (Cronbach's alpha = 0.95). Therefore, the results collected, based on a step-by-step confirmation approach, are reliable.

4.5.3. Personal information relative to the discomfort in body regions

(1) Gender

Table 4.2 indicates that the females felt more discomfort in body regions than the males but not significantly so ($p>0.05$), except for neck discomfort where the Pearson $\chi 2$ test indicated that gender was a significant factor ($p < 0.05$).

Table 4.2. Gender effect on discomfort in body regions.

	Female (n=176)	Male (n=46)	Mean	Rank
Lower back	2.31	2.22	2.27	1
Right-shoulder	2.09	1.87	1.98	2
Neck*	2.06	1.73	1.90	3

* Pearson chi-square test identified the significant effect of gender on neck discomfort (p=0.021).

(2) Age

As can be seen in Table 4.3, the average age of hairdressers was 23.25 years and the range was 15 to 46 years. Also in Table 4.3, the Pearson $\chi 2$ test indicated that the overall discomfort level in the left hand/finger and the right forearm was significantly different in these age categories ($p< 0.05$).

Table 4.3. The effect of age on the overall discomfort in the body region (n=220).

Body region	Pearson chi-square ($\chi2$)	Sig. (2-sided)
Neck	12.54	p = 0.403
Left-shoulder	16.2	p = 0.18
Left-upper arm	14.16	p = 0.29
Left-forearm	18.75	p = 0.1
Left hand/finger *	24.24	p = 0.019
Right-shoulder	13.4	p = 0.34
Right-upper arm	16.1	p = 0.19
Right-forearm *	23.47	p = 0.024
Right-finger/hand	14.73	p = 0.256
Lower back	15.44	p = 0.218

* The Pearson chi-square test indicated that age had a significant effect of on the overall discomfort in the various body regions ($p<0.05$)

(3) Job levels

The participants' job levels are categorised as follows: (1) up to 1 year junior technician, (2) 1 to 2 years senior technician, (3) senior technician, (4) 1~5 years experienced junior hairdresser and (5) over 5 years experienced senior hairdresser. As a result, the Pearson $\chi2$ test showed that the overall discomfort level in body regions and trouble due to WMSDs were not significantly different in these five job levels ($p>0.05$). Therefore, the study suggests that the higher-level jobs did not significantly increase workload.

4.5.4. Working conditions

(1) Work experience

The mean work experience was 63.5 months. The Pearson $\chi2$ test indicated that the overall discomfort level in body regions and trouble due to work-related musculoskeletal disorders was not significantly different in the work experience categories ($p>0.05$).

(2) Working days per week

The average number of working days per week was 6. The Pearson $\chi 2$ test indicated that the overall discomfort level in body regions and trouble due to WMSDs were not significantly different in the average number of working days categories ($p>0.05$).

(3) Working hours per day

The participants are required to answer the question "How many days do you work every week?". As a result, the average number of working hours per day was 11.39. The Pearson $\chi 2$ test indicated that the overall discomfort level in body regions is not significantly different in the working hours per day categories ($p>0.05$).

(4) Standing hours per working day

The participants are required to answer the question "How many hours do you stand for the working day?". As a result, the mean standing hours per working day of hairdressers was 8.3. In comparison with the mean working hours per day, which was 11.39, hairdressers spent over 72% of the time standing every working day. Furthermore, the Pearson $\chi 2$ test indicated that the trouble due to work-related musculoskeletal disorders was not significantly different in the standing hours categories ($p>0.05$).

(5) Taking breaks

The participants are required to answer the question "Do you take breaks during your work?". As a result, over 24% of the participants reported taking no breaks during their work, whilst over 50% of the participants reported that taking a break depended on the situation. The Pearson $\chi 2$ test also reveals that the overall discomfort level in body regions and the trouble due to work-related musculoskeletal disorders were not significantly different in these three categories of answers (p>0.05).

4.5.5. Relationship between techniques and discomfort in body regions

(1) Techniques

As can be seen in Table 4.4, the descriptive statistic indicated that 95% of the participants performed hair-washing daily, following by hair-colouring (84%), hair-perming (81%), hair-blow-drying (72%) and hair-cutting (68%).

Table 4.4. Daily Techniques being performed (n=220, multi-selection).

	Hair-washing	Hair-cutting	Hair-perming	Hair-colouring	Blow-drying
Counts	189 (95)	136 (68)	161 (81)	167 (84)	143 (72)

Note: Percentages (in parentheses) do not total 100 as they are proportions of the total respondents.

(2) Subjective opinion for improvement of hairdressing techniques

As can be seen in Table 4.5, the multi-selection test indicated that 55% of the subjects hoped to improve their hair-washing technique as a first priority, followed by the techniques of hair-blow-drying (28%) and hair-cutting (25%). By contrast, the task which was in least need of improvement was hair-colouring (40%), which was 5th in priority among these five tasks.

Table 4.5. Subjective opinion about which task needed for improvement (nodes = 861) (n=220).

	Hair-washing	Blow-drying	Hair-cutting	Hair-perming	Hair-colouring
1st priority	474(55)	138(16)	52(6)	52(6)	181(21)
2nd priority	189(22)	241(28)	129(15)	112(13)	138(16)
3rd priority	103(12)	215(25)	224(26)	181(21)	155(18)
4th priority	77(9)	181(21)	276(32)	224(26)	52(6)
5th priority	17(2)	86(10)	181(21)	293(34)	344(40)

Note: Percentages (in parentheses) do not total 100 as they are proportions of the total respondents.

(3) Top ten most uncomfortable body regions associated with particular tasks

The mean discomfort levels of the body regions for the various tasks are shown in Table 4.6. Among these body regions, if the mean discomfort level is more than 1.0, the task associated with this body region can lead to WMSDs. Thus, hair-washing, blow-drying and hair-cutting task were the three tasks that must be improved as the result found that these tasks caused the most serious discomfort in the lower back, right-shoulder and neck.

Table 4.6. Top ten most uncomfortable body regions associated with particular tasks (n=220).

Task	Body Region	Discomfort Level (mean ± S.D.)
Hair-washing	Lower back	2.35 ± 1.37
	Right-shoulder	1.98 ± 1.33
	Neck	1.89 ± 1.29
	Left-shoulder	1.86 ± 1.35
Hair-blow-drying	Right-shoulder	1.88 ± 1.35
	Right-upper arm	1.79 ± 1.25
	Lower back	1.71 ± 1.19
	Right-forearm	1.7 ± 1.25
Hair-cutting	Right-finger/hand	1.74 ± 1.13
	Lower back	1.72 ± 1.3

4.5.6 Overall discomfort in body regions

Based on the mean discomfort level in the body regions for the five tasks shown in Table 4.7, the body regions with most discomfort were the lower back (2.35), right-shoulder (1.98) and neck (1.89). The result corresponds with those in the questionnaire survey. As a result, the body regions with the most discomfort were the lower back (2.3), followed by the right-shoulder (2.0) and neck (1.9). Both results were consistent with the earlier study.

Table 4.7. Overall discomfort in the body regions.

		Neck	Left shoulder	Left upper arm	Left forearm	Left hand/finger	**Right shoulder**	Right upper arm	Right forearm	Right finger/hand	**Lower back**
Female (n=175)	Mean	2.1	1.9	1.6	1.5	1.7	2.1	1.8	1.7	1.8	2.3
	S.D.	1.3	1.3	1.1	1.1	1.2	1.3	1.2	1.2	1.2	1.3
	Min	0	0	0	0	0	0	0	0	0	0
	Max	4	4	4	4	4	4	4	4	4	4
Male (n=45)	Mean	1.7	1.6	1.4	1.2	1.5	1.9	1.6	1.4	1.6	2.2
	S.D.	1.5	1.4	1.3	1.2	1.2	1.5	1.4	1.3	1.3	1.5
	Min	0	0	0	0	0	0	0	0	0	0
	Max	4	4	4	4	4	4	4	4	4	4
Total (n=220)	Mean	**1.9**	1.8	1.5	1.4	1.6	**2.0**	1.7	1.5	1.7	**2.3**
	S.D.	1.4	1.3	1.2	1.1	1.2	1.4	1.3	1.3	1.2	1.4
	Min	0	0	0	0	0	0	0	0	0	0
	Max	4	4	4	4	4	4	4	4	4	4

4.5.7. Effects and causes of discomfort

As can be seen in Figure 4.4, 78.2 % of the participants reported partial agreement that work-related musculoskeletal disorders were related to their hairdressing career, and 15.9% of the participants totally agreed.

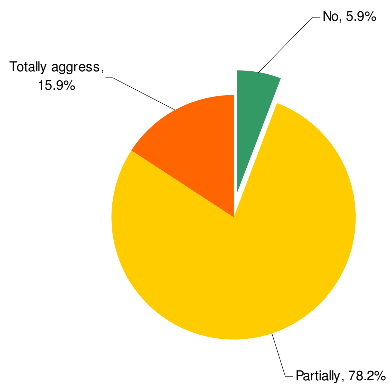

Figure 4.4. Connection between hairdressing career and WMSDs (n=220)

As can be seen in Figure 4.5, only 18.6 % of the participants report that WMSDs do not affect their daily life, whist 46.8% of the participants reported that WMSDs did affect their daily life. Moreover, 28.2% of the participants reported, “I am not able to perform my job owing to work-related musculoskeletal disorders”.

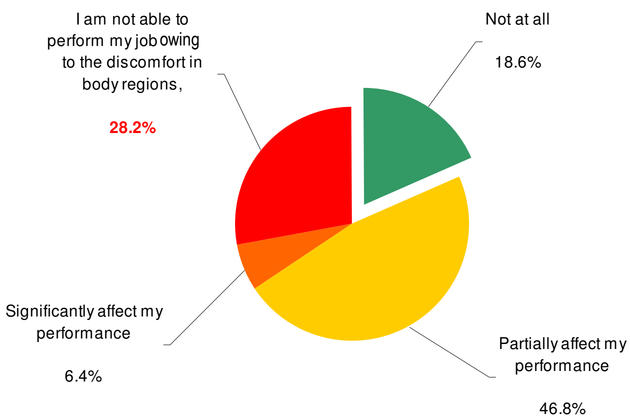

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Figure 4.5. Occurrence of accident due to WMSDs (n=220)

As can be seen in Figure 4.6, 14.1% of the participants reported that they used to take sick leave due to work-related musculoskeletal disorders.

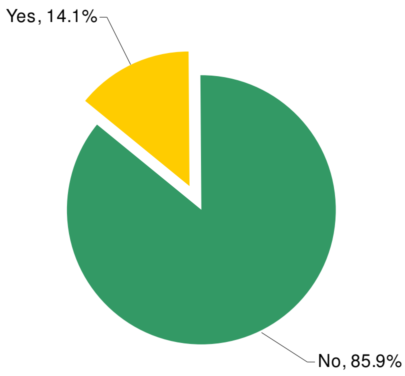

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Figure 4.6. Sickness leave due to WMSDs (n=220)

4.6. Discussion

The survey examined the risk factors for WMSDs among Taiwanese hairdressers by relating techniques with discomfort levels in different body regions. The pilot study was conducted in order to examine the inter-reliability of the questionnaire design and initially explore the risk factors among twelve participants. Based on the pilot study (Fang *et al.*, 2007), the questionnaire design was improved. After that, two hundred and twenty professional hairdressers were randomly selected from twenty-six different hair salons in Taiwan.

Among the five hairdressing techniques considered, the body regions with the highest mean discomfort levels were, starting with the highest, the lower back, right-shoulder and neck. The results are slightly different from the previous studies. This study covers the body regions of the sample population and has produced a large amount of data (n=220), thereby suggesting that this research could reflect the discomfort experienced by members of the hairdressing profession in Taiwan.

Regarding its findings, firstly, the study confirms that no significant relationship exists between the discomfort in various body regions and work experience, weekly working days, working hours, working hours spent standing and the frequency of taking a break. In addition, further findings show that: firstly, females are likely to feel more discomfort than males but not significantly so, except in the neck ($p<0.05$).

Secondly, hairdressers in different age categories are likely to suffer significantly different levels of overall discomfort in particular body regions, i.e. left hand/finger, right upper arm and right forearm. Thirdly, the higher the job level, the more different techniques have been used, but this does not increase workload. Finally, females and males have an equal opportunity to obtain the same level of job position because there is no significant relation between gender and job level.

Regarding the effect of age, the overall discomfort level in left hand/finger and right forearm was found to be significant. Thus the workload might cause the discomfort in specific body regions, besides, ageing could also have an effect on the muscle activity and kinematic function. Nevertheless, further investigation needs to be made, using a quantitative method, to validate the relation between the techniques and risk factors of working postures among hairdressers in Taiwan.

With respect to the techniques associated with discomfort in body regions, since the effect of hair-washing and of hair blow-drying techniques on discomfort in the lower back is significant, the improvements in these can be expected to improve the discomfort level in the lower back. Moreover, the techniques of hair-washing, blow-drying and hair-cutting are associated with the highest discomfort levels in the lower back, right-shoulder and right finger/hand. It is here that the improvement of techniques is recommended as the first priority.

Regarding the working hours per day, the average working hours per day was 11.39. Although the Pearson chi-square test indicated that the overall discomfort level in body regions is not significantly different in the working hours categories ($p>0.05$), the Pearson chi-square test indicated that the long working hours significantly increase the rate of sickness ($\chi 2 = 6.92$, $p<0.05$): over 40% of participants who worked over 11 hours per day reported having sick leave due to WMSDs. The result highlights the urgent need to reduce the working hours to an official standard, say eight hours per working day.

4.7. Conclusions

This study emphasises that there is a need to investigate the status of work-related musculoskeletal disorders for hairdressers in Taiwan as a first step towards their prevention. Thus, this study has examined the risk factors for work-related musculoskeletal disorders among Taiwanese hairdressers by relating techniques with discomfort levels in 10 different body regions. This study has achieved an acceptable inter-reliability for the questionnaire survey.

This research examines a wide range of the risk factors for WMSDs among Taiwanese hairdressers who use different hairdressing techniques and experience levels of discomfort in particular body regions. The questionnaire contains four groups of questions: personal details, the working conditions, the self-awareness associated with five hairdressing techniques and the effects and causes of discomfort. The results show that the mean value for the levels of discomfort in different body regions, starting with the highest, were found to be in the lower back, followed by the right-shoulder and the neck.

Based on a quantitative questionnaire survey, this study has made a contribution to the hairdressing industry in Taiwan by linking discomfort in specific body regions with particular hairdressing techniques. The study also confirms that there is no significant relation between the discomfort in body regions and work experience, weekly working days, working hours, working hours spent standing and the frequency of taking a break.

With respect to hairdressing techniques associated with WMSDs, since the effect of hair-washing and hair blow-drying techniques on the discomfort level in the lower back is significant ($p<0.05$), an improvement of both techniques should be made in order to effectively lessen the WMSDs in the upper limb and lower back.

Since the techniques of hair-washing, blow-drying and hair-cutting are associated with the highest overall discomfort levels in the lower back, right-shoulder and neck, these techniques are recommended for further investigation with a view to their improvement in the future. Through the use of a quantitative questionnaire survey in Taiwan, the findings appear to have achieved the aim of this research, which was to link discomfort in specific body regions to particular hairdressing techniques.

As hairdressing techniques consist of typical working procedures in real working situations which cannot be found without observing their working postures, it will therefore be important to observe actual hairdressing working postures to identify hairdresser's movements which can then form the basis for the further investigation of ergonomics intervention training.

Chapter Five: Postural Analysis of the Upper Limb Regions

5.1. Introduction

5.1.1. Background

Observation methods have frequently been used to estimate work postures and work movements in studies of work-related musculoskeletal disorders (Juul-Kristensen *et al.*, 2001). With video observation, which is a semi-quantitative method used to assess ergonomic risk factors such as awkward postures, there are several advantages such as high portability, reasonably low equipment costs, a high level of detail, the ability to obtain data for large populations with minimal disruption to the workplace and the generation of permanent records of job tasks (Dartt *et al.*, 2009). However, direct measures are often associated with high costs, time consumption and subject interference (Li and Buckle, 1999). Furthermore, the disadvantages can include long and detailed observer training, lengthy analysis time and an inadequate camera setup for dynamic tasks (Dartt *et al.,* 2009).

When reviewing the literature, various methods are found to assess the postures, movements and forces. The video recording method is commonly used as a basis for posture analysis; it has been applied to the assessment of exposure to various risk factors. There are many assessment tools to expose the risk factors of the work-related musculoskeletal disorders. One of these is the Rapid Upper Limb Assessment (RULA) method developed by McAtamney and Corlett (1993) for use in ergonomics investigations in workplaces where there is a risk of work-related upper limb disorders.

RULA is a tool that allows the evaluation of loads due to work posture, muscles used and force exerted and the calculation of the exposure to the risk factors associated with work-related upper limb disorders. RULA is also a validated tool that assesses biomechanical and postural loading on the upper limbs. According to this method, a score is calculated for the posture of each body part, which is divided into sections according to criteria. These sections are numbered so that the number 1 is given to the range of movement or working posture where the risk factors present are minimal, as explained by McAtamney and Corlett (1993).

Qualitative methods have been needed in this chapter to support the findings of the questionnaire survey as a part of the development of an evaluation procedure for the ergonomics intervention training.

5.1.2. Aim and objectives

The study aimed to evaluate the risk level of the 21 selected working postures used for hairdressing techniques, in turn, the most critical, awkward, working postures found in hairdressing techniques were identified for further improvement. The working postures have been considered for four hairdressing techniques: hair-washing in a standing position, hair-washing in the washbasin area, hair-straightening and hair blow-waving. A well-known and validated web-based RULA tool will be employed for the evaluation of the risk level of the technique for further improvement based on the ergonomics training programme in Chapter 6.

In order for this to be achieved, the following objectives need to be met:

1. To record 12 professional hairdressers evaluating the risk level of the selected 21 working postures used for the hairdressing techniques, using vide record and static

photographs.

2. To identify the most risky parts of the working postures by conducting a critical analysis of the RULA analysis results;
3. To compare the results of the critical analysis, discuss the analysis, summarise the findings and draw conclusions.

5.1.3. Research limitation

In order to fulfil a particular objective for a client, a hairdresser is required to perform various hairdressing techniques. Thus, a large number of complex working postures are involved, which are difficult to pre-define and classify. Moreover, working postures within each hairdressing technique are not necessarily operated in sequence. Therefore, the analysis of high-risk working postures is very subjective in terms of the individual differences that rely on data analysis based on the well-defined duration and repetition of particular high-risk working postures.

5.2. Method

5.2.1. Participant selection criteria

After the questionnaire surveys, six hair salons were asked to participate in this observation study, although only one salon agreed to the use of video recording. In total, this involved twelve experienced female hairdressers who met the selection criteria described in section 4.3.1 above.

5.2.2. Testing apparatus

The hair salon used for the experiment is in the Department of Styling and Cosmetology at Tainan University of Technology, Taiwan. The salon has been in operation since 1994 and currently has 12 full-time hairdressers working there. This experiment was conducted using the following equipment:

- Web-based RULA;
- Two digital Video cameras (DV) to record participants' performance during the experiment;
- Blow-dryer;
- Brushes;
- Hair-strengthening iron;
- Combs;
- Microsoft Excel™ XP.

5.2.3. Experimental procedure

In the real situation, a hairdresser is required to perform various daily techniques to fulfil his/her job to satisfy the client's need. Each technique consists of various hairdressing and associated working postures to achieve the goal, which implies a dynamic working posture to utilise various body regions skilfully with various related items of equipment. The relationship between the hairdressing job, the techniques, job descriptions and working postures are illustrated in Figure 5.1.

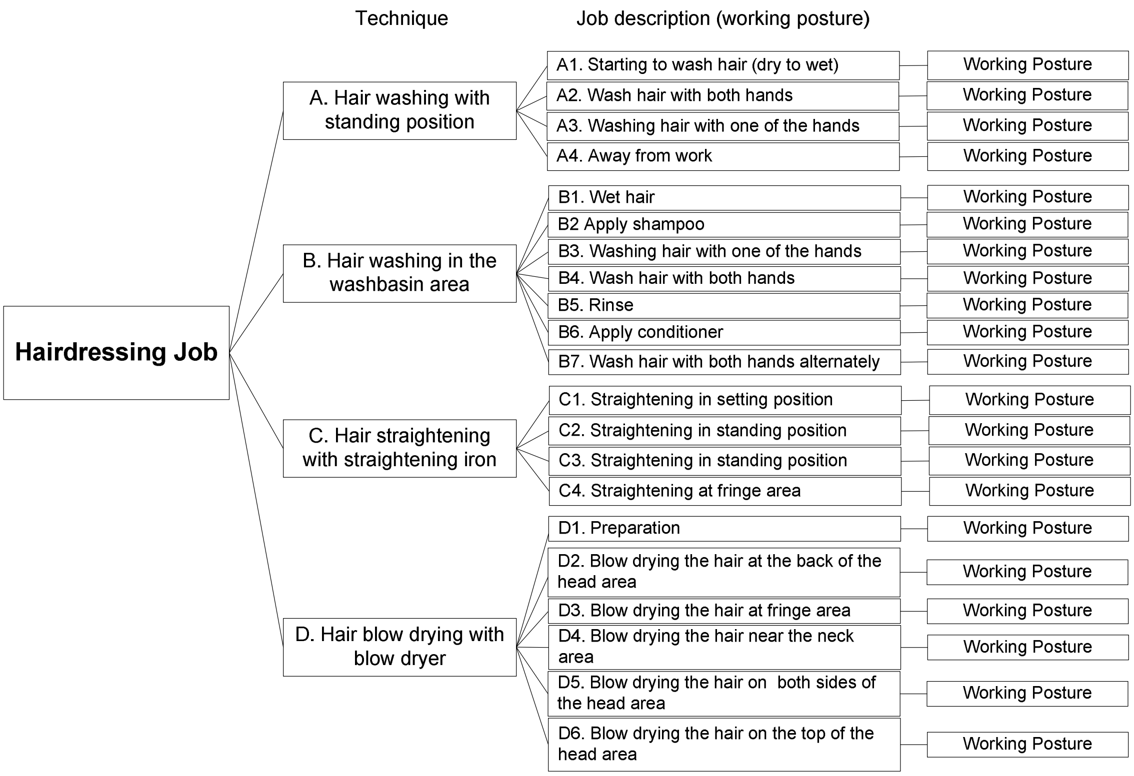

Figure 5.1. The relationship between the hairdressing job, the techniques, job descriptions and working postures.

The observations of the techniques summarized in Table 5.1 were conducted with these twelve qualified hairdressers.

Table 5.1. Hairdressing techniques that were recorded.

Job descriptions	Action Code	No. of techniques
Hair washing with standing position	A	4
Hair washing in the washbasin area	B	7
Hair straightening with straightening iron	C	4
Hair-blow-waving with blow-dryer	D	6
Total		21

The observation method using the video recorder is employed to observe the hairdresser's daily job based on post-video analysis. Static photos of the working postures involved in the functional techniques were taken from the post-video file. The standard operation procedure for the observation will be discussed in the following section.

5.2.4. Standard Operation Procedure (SOP)

A standard operation procedure (SOP), shown in Figure 5.2, was used as a checklist to ensure reliability of the observation and the related analysis. There were four sections in the experiment.

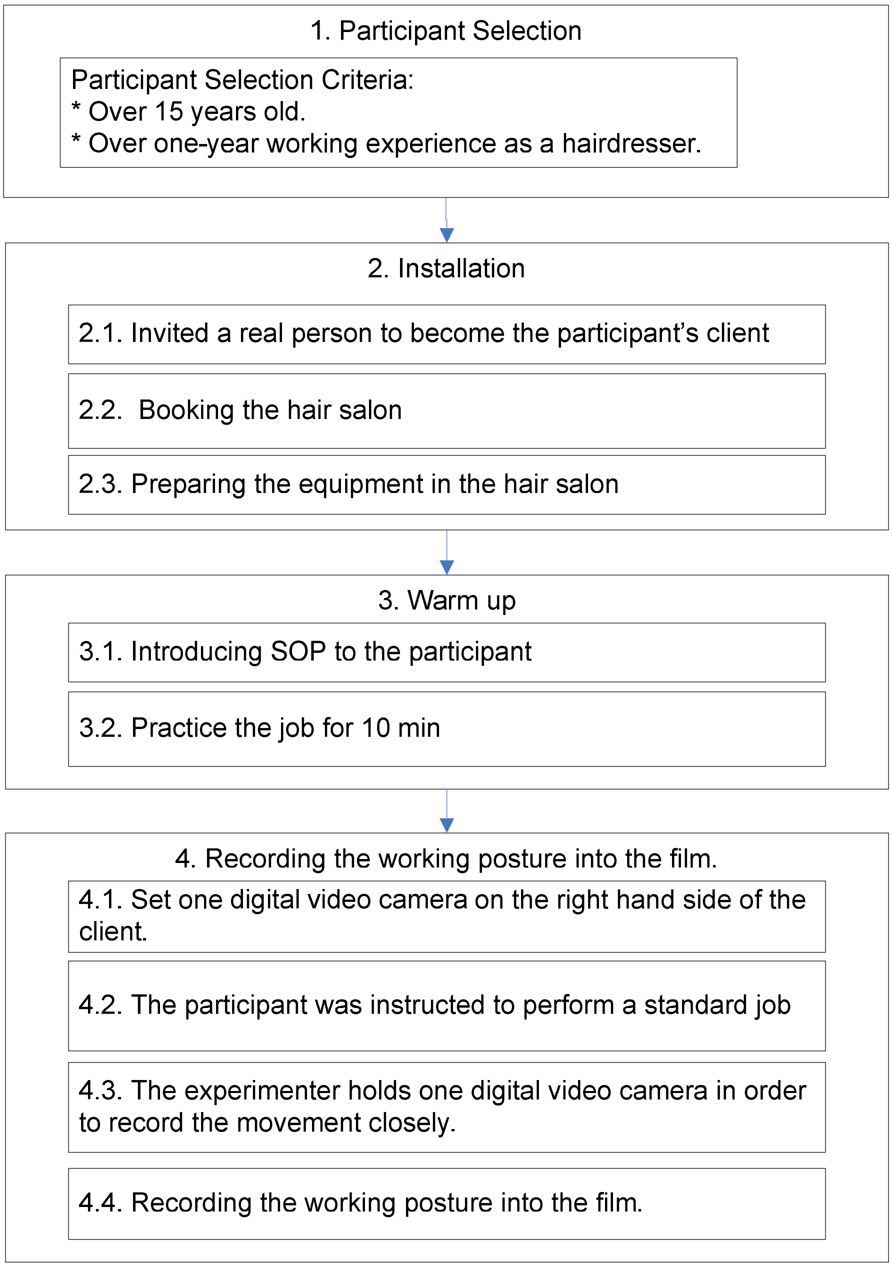

Figure 5.2. Standard operation procedure (SOP) for the observation in Chapter 5.

In section 1, twelve professional Taiwanese hairdressers who met the selection criteria volunteered to join this study. In section 2, the observation took place in the subject's job location, i.e. hair salon. Instead of using manikin hair for the performance of the daily techniques, the study invited a real person to become the participant's client. The participants were allowed to use their own equipment if it was regular in size and shape. Photos of the equipment used were taken for future reference.

In section 4, the participant was instructed to perform a standard job using the techniques according to the definition. The video was taken using two digital video cameras (DV).

In the section 4, the participant was instructed to perform a standard job using the techniques according to the definition. The video was taken via two digital video cameras (DV).

5.3. Analysis

5.3.1. Introduction

In order to evaluate the risk level for experiencing WMSDs with these hairdressers, this study employs the RULA online scoring system to gather overall score for the 21 selected working postures of the four hairdressing techniques. It aims to evaluate the risk level for experiencing WMSDs from the static photos associated with these 21 selected working postures associated with these four hairdressing techniques.

5.3.2. Participants' information

Participants’ ages range from 19 to 32 years, with a mean of age of 22.7 years; their work experience average was 70 months, with a range of 15 to 156 months and their mean working hours per week was 49.58 hours. Thus, all participants met the selective criteria of eighteen plus years old, working fulltime and with more then one-year's work experience. All of them had obtained a Level C in the Certificate of Technician of Hairdressing to minimize the individual differences.

5.3.3. Rapid Upper Limb Assessment (RULA)

In order to gather the static photos used for the RULA analysis, the following procedures were used with the web-based RULA tool, see Figure 5.3, below.

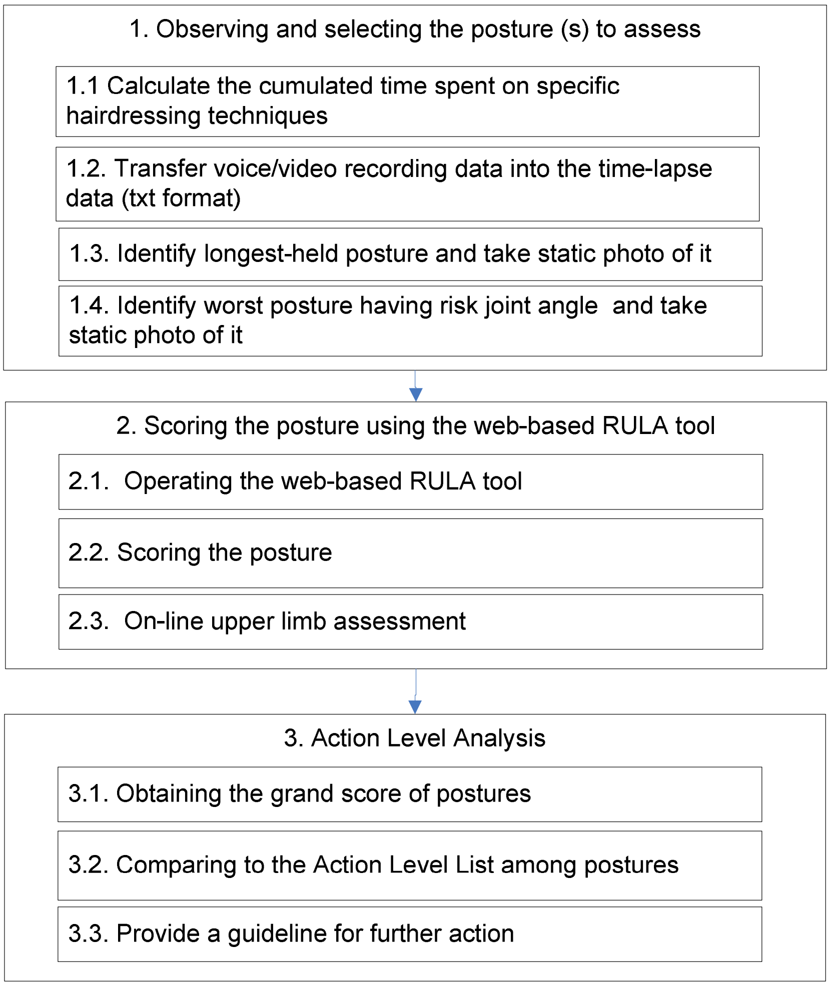

Figure 5.3. Standard operation procedure (SOP) for the web-based RULA tool.

(1) Observing and selecting the posture (s) to assess

Step 1 aims to identify the techniques that are representative of the extreme joint angles of a working posture. Depending upon the type of study, selection may be made of the longest-held posture or what appears to be the 'worst' posture(s) adopted. In some instances, for example when the work cycle is long or the postures are varied, it may be more appropriate to make an assessment at regular intervals. It will be evident that if assessments are taken at set intervals over the working period, the proportion of time spent in the various postures can be evaluated. The static photos of these 21 selected working postures and associated job descriptions are summarised in section 5.3.4.

A freeware qualitative statistical tool, "Trans Tool", which is widely used by qualitative researchers in Taiwan, was employed to calculate the cumulative time spent on specific hairdressing techniques, as shown in Figure 5.4.

Figure 5.4. The user interface of the Trans Tool
(See more detail of the software, please see http://mydoztrans.googlecode.com/).

The import file is the video recording data in mpeg/mpg format, and the output file is the time-lapse data (i.e. txt format) in terms of ID, start time, end time, code and duration (sec). Based on the time-lapse data, it is possible to “quantity” the time spent on awkward working postures during the specific hairdressing techniques. An example of the output data is shown in Table 5.2. For further detail, please see Appendix F: “Raw Data Obtained from the Observation based on Twelve Hairdressers in Taiwan”.

Table 5.2. A sample of the time-lapse data in .txt format, showing the output data for participant ID 001.

ID	Start Time	End Time	Code	Duration (sec)	Remarks
001	[00:00:16.02]	[00:01:03.55]	A1	48.0	A1: Starting to wash hair (dry to wet) A2: Wash hair with both hands A3: Washing hair with one of the hands A4: Away from work
001	[00:01:11.10]	[00:01:15.76]	A3	5.0	
001	[00:01:16.80]	[00:01:21.60]	A2	5.0	
001	[00:01:22.40]	[00:01:24.40]	A3	2.0	
001	[00:01:24.51]	[00:01:29.86]	A2	5.0	
001	[00:01:38.48]	[00:01:56.92]	A4	19.0	
001	[00:02:00.30]	[00:02:20.54]	A1	21.0	
001	[00:02:24.02]	[00:02:37.53]	A2	14.0	
001	[00:02:42.39]	[00:03:02.86]	A3	21.0	
001	[00:03:04.26]	[00:03:15.99]	A2	12.0	
001	[00:03:18.01]	[00:03:20.85]	A3	3.0	
001	[00:03:21.98]	[00:03:25.08]	A2	3.0	
001	[00:03:26.22]	[00:03:34.91]	A3	9.0	
001	[00:03:35.92]	[00:03:50.26]	A2	14.0	
001	[00:03:51.08]	[00:04:23.13]	A3	32.0	
001	[00:04:23.99]	[00:04:29.34]	A2	5.0	
001	[00:04:32.03]	[00:04:45.33]	A3	13.0	
001	[00:04:46.24]	[00:05:10.23]	A2	24.0	
001	[00:05:11.30]	[00:05:14.83]	A3	4.0	
001	[00:05:15.90]	[00:05:35.84]	A2	20.0	
001	[00:05:36.82]	[00:05:39.47]	A3	2.0	
001	[00:05:40.36]	[00:05:43.18]	A2	3.0	
001	[00:05:43.94]	[00:05:52.98]	A3	9.0	
001	[00:05:53.87]	[00:06:15.23]	A2	21.0	
001	[00:06:16.39]	[00:06:18.87]	A3	3.0	
001	[00:06:19.88]	[00:07:01.08]	A2	41.0	

Static photos of specific postures were taken for further analysis of the joint angles of postures. The digital video data was transferred onto DVDs after recording then encoded and the static pictures of the working postures of the four major hairdressing techniques were taken, in particular of those working postures which seemed to have more extreme joint angles of over 25^{o} from the neutral posture. Hence, multiple photos were taken for each selected hairdressing technique (see Figure 5.5).

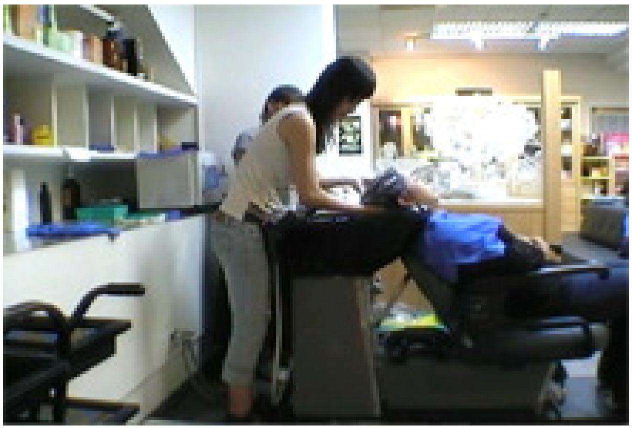

Figure 5.5. Static pictures were taken from digital video for the working posture analysis.

(2) Scoring the posture using the web-based RULA tool

In Step 2, the postures were scanned using the web-based RULA tool. These representative photos illustrate the working posture of the upper limb, thus the RULA analysis result includes both the right and left limb. Regarding the way to operate the web-based RULA tool (source: http://www.rula.co.uk/), an example for the online scoring of RULA is described in Appendix E.

(3) Acton Level Analysis

Step 3 aims to obtain the action level for further action. The overall score can be generated by the on-line tool and compared to the Action Level List. There are four risk action levels that require an improvement of the working posture when carrying out the associated hairdressing techniques, shown as follows:

Action level 1: An overall score of 1or 2 indicates that the posture is acceptable if it is not maintained or repeated for long periods.

Action level 2: An overall score of 3 or 4 indicates that further investigation is needed and changes may be required.

Action level 3: An overall score of 5 or 6 indicates that investigation and changes are required soon.

Action level 4: An overall score of 7 or more indicates that investigation and changes are required immediately.

However, it must be remembered that, since the human body is a complex and adaptive system, it is only a guide for further action. In most cases, it is necessary to ensure this guide will be used as an aid to secure the efficient and effective control of any risks identified and to ensure that the actions lead to a more detailed investigation.

The overall score of 21 working postures can be seen in Tables 5.3 to 5.5.

Table 5.3. Summary of the overall score of RULA in right upper limb for 21 working postures.

Techniques	Working Posture	Risk Posture?	Right Upper Limb					
			Force and load	Right Shoulder	Right Upper Arm	Right Lower Arm	Right Wrist	Right Wrist Twist
A	A1	Y	0	1	2	2	3	1
A	A2	Y	0	1	3	2	3	1
A	A3	Y	0	1	3	2	3	1
A	A4		0	0	0	0	0	0
B	B1		0	0	0	0	0	0
B	B2		0	0	0	0	0	0
B	B3	Y	0	1	3	1	3	1
B	B4	Y	0	1	2	2	3	1
B	B5	Y	0	1	2	2	3	1
B	B6		0	0	0	0	0	0
B	B7	Y	0	0	4	2	3	1
C	C1	Y	0	1	4	2	3	2
C	C2	Y	0	1	3	2	3	2
C	C3	Y	0	1	4	2	3	2
C	C4	Y	0	1	3	2	3	2
D	D1		0	0	0	0	0	0
D	D1	Y	1	1	3	2	3	2
D	D1	Y	1	1	4	2	3	2
D	D1	Y	1	1	3	2	3	2
D	D1	Y	1	0	2	2	3	1
D	D1	Y	1	1	3	2	3	2

Table 5.4. Summary of the overall score of RULA in left upper limb for 21 working postures.

Techniques	Working Posture	Risk Posture?	Left Upper Limb					
			Force and load	Left Shoulder	Left Upper Arm	Left Lower Arm	Left Wrist	Left Wrist Twist
A	A1	Y	0	1	3	2	3	1
A	A2	Y	0	1	3	2	1	1
A	A3	Y	0	1	2	2	3	1
A	A4		0	0	0	0	0	0
B	B1		0	0	0	0	0	0
B	B2		0	0	0	0	0	0
B	B3	Y	0	1	3	1	3	1
B	B4	Y	0	1	2	2	3	1
B	B5	Y	0	1	3	2	3	1
B	B6		0	0	0	0	0	0
B	B7	Y	0	1	3	2	3	1
C	C1	Y	0	1	3	2	3	2
C	C2	Y	0	1	3	2	3	2
C	C3	Y	0	1	3	2	3	2
C	C4	Y	0	1	3	2	3	2
D	D1		0	0	0	0	0	0
D	D2	Y	0	1	3	2	3	2
D	D3	Y	0	1	4	2	3	2
D	D4	Y	0	1	3	2	3	2
D	D5	Y	0	0	2	2	3	1
D	D6	Y	0	1	3	2	3	2

Table 5.5. Summary of the overall score of RULA in neck, trunk, legs and final result of right and left upper limbs for 21 working postures

Techniques	Working Posture	Risk Posture?	Neck, trunk and leg							Result of RULA	
			Neck	Neck Twist	Neck Sidebend	Trunk	Trunk Twist	Trunk Sidebend	Legs	Right upper limb	Left upper limb
A	A1	Y	1	0	0	1	0	0	1	3	3
A	A2	Y	2	0	0	1	0	0	1	3	3
A	A3	Y	2	0	0	1	0	0	1	3	3
A	A4		0	0	0	0	0	0	0	0	0
B	B1		0	0	0	0	0	0	0	0	0
B	B2		0	0	0	0	0	0	0	0	0
B	B3	Y	3	0	0	3	0	0	1	5	5
B	B4	Y	3	0	0	3	0	0	1	4	4
B	B5	Y	3	0	0	3	0	0	1	4	5
B	B6		0	0	0	0	0	0	0	0	0
B	B7	Y	3	1	1	3	1	1	4	6	7
C	C1	Y	1	0	1	1	0	1	1	6	4
C	C2	Y	2	0	0	1	0	1	1	4	4
C	C3	Y	1	0	0	1	0	0	1	5	4
C	C4	Y	2	0	1	1	0	1	1	5	5
D	D1		0	0	0	0	0	0	0	0	0
D	D2	Y	2	0	0	2	0	0	1	4	4
D	D3	Y	1	0	0	1	0	0	1	5	5
D	D4	Y	2	0	0	1	0	0	1	4	4
D	D5	Y	2	0	0	1	0	0	1	4	3
D	D6	Y	2	0	0	3	0	0	1	6	6

5.3.4. Postural analysis with the colour label

In total, 129 photos of risky working postures were taken for this research, and 21 of these were retained as representative photos for the RULA analysis. The job descriptions of these 21 identified representative working postures that appear during hairdressing techniques are described in Tables 5.6 to 5.9.

These photos illustrate the working postures of the upper limb, thus the RULA analysis result includes both the right and left limb. The risk score is represented as the action level (R/L) in the following tables. The colour label is used for this study in order to illustrate the action level, of each critical level with the following meanings:

Critical level 1: Further investigation is needed and changes may be required (i.e. the action level is ranked as 3 or less);

Critical level 2: Changes are required soon (i.e. the action level is ranked from 4 between 5, inclusive);

Critical level 3: Investigation and changes are required immediately (i.e. the action level is ranked as 6 and above).

Table 5.6. Action level (R/L) of hair washing in the standing position (Code No: A).

Code No.	Job description	Static pictures and the action level (R/L) with the colour label*	Description of working posture
A1	Starting to wash hair (dry to wet)	**Action Level (3/3)** 	Both upper arms are abducted 45° to 90°, shoulder is raised, one wrist is holding a bottle of water weighing less than 2kg, and the another wrist shows radial deviation and twist, neck and trunk are rare twist or side bend, standing all the time, posture is mainly repeated more then 4 times per minute.
A2	Wash hair with both hands	**Action Level (3/3)** 	Both upper arms are abducted 45° to 90° at same time, shoulder is raised, both wrists are bent in radial and ulnar deviation as the action taken, neck and trunk are rare twist or side bend, standing all the time, posture is mainly repeated more then 4 times per minute.
A3	Washing hair with one of the hands	**Action Level (3/3)** 	One upper arm is abducted 45 ° to 90 °, shoulder is raised, other upper arm and shoulder are static on head, wrist in ulnar deviation at moved hand, other one is static, neck and trunk are rare twist or side bend, standing all time, posture is mainly repeated more then 4 times per minute.
A4	Away from work	No picture required.	Take the shampoo to the washbasin from the client's head.

* The colour label is used in order to illustrate the risk level, of each critical level with the following meaning:

Critical level 1: Further investigation is needed and changes may be required (i.e. the action level is ranked as 3 or less);

Critical level 2: Changes are required soon (i.e. the action level is ranked from 4 to 5, inclusive);

Critical level 3: Investigation and changes are required immediately (i.e. the action level is ranked as 6 and above).

Table 5.7. Action level (R/L) of hair washing in the washbasin area (Code No: B).

Code	**Actions**	**Static pictures and RULA action level (R/L) with the colour label**	**Description of working posture**
B1	Wet hair	No picture required.	Wet hair
B2	Apply shampoo	No picture required.	Apply shampoo
B3	Washing hair with one of the hands	**Action Level (5/5)** 	One upper arm is abducted 45^{o} to 90^{o}, shoulder is raised, other upper arm and shoulder are raising the head, wrist is bent in extension as the action taken, neck and trunk are mainly bent to reach the washbasin, standing all time, posture is mainly static held longer than 1 minute.
B4	Wash hair with both hands	**Action Level (4/4)** 	Both upper arms are abducted 20^{o} to 45^{o} at the same time, shoulder is raised, both wrists are bent in extension as the action taken, neck and trunk are mainly bent to reach the washbasin, standing all the time, posture is mainly static held longer than 1 minute.
B5	Rinse	**Action Level (5/4)** 	One upper arm is abducted 45^{o} to 90^{o}, shoulder is raised, other upper arm and shoulder are holding the tap for supplying the water, both wrists are bent in extension as the action taken, neck and trunk are mainly bent to reach the washbasin, standing all time, posture is mainly static held longer than 1 minute.
B6	Apply conditioner	No picture required.	Apply conditioner.
B7	Wash hair with both hands alternately	**Action Level (7/6)** 	One upper arm is abducted over 90^{o}, shoulder is raised, other upper arm is abducted 45^{o} to 90^{o} and shoulder is raised, both wrists are bent in extension and flexion as the action taken, neck and trunk are mainly bent and twisted to reach the washbasin, standing at the side of washbasin with one leg, posture is mainly static held longer than 1 minute.

Table 5.8. Action level (R/L) of hair straightening with straightening iron (Code No: C).

Code	**Actions**	**Static pictures and RULA action level (R/L) with the colour label**	**Description of working posture**
C1	Straightening in setting position	Action Level (6/4) 	Sitting on the stool, right upper arm is abducted up to 90 ^{o}, left upper arm is abducted 45 ^{o} to 90 ^{o}, right hand holds the straightening iron with force to straighten the back hair of the head, neck and trunk are slightly side-bending, and posture is mainly repeated more then 4 times per minute.
C2	Straightening in standing position (Back of the head area)	Action Level (4/4) 	Right hand holds the straightening iron with force to straighten the top hair of the head. Neck and trunk are slightly side-bending.
C3	Straightening in standing position (Top of the head area)	Action Level (5/4) 	Both upper arms are abducted up to 90 ^{o} and slightly down to up 60 ^{o}, right hand holds the straightening iron with force to straighten the top hair of the head, neck and trunk are slightly side-bending.
C4	Straightening at fringe area	Action Level (5/5) 	Neck and trunk are slightly side-bending to reach the target.

Table 5.9. Action level (R/L) of hair-blow-waving with blow-dryer (Code No: D).

Code	**Actions**	**Static pictures and RULA action level (R/L) with the colour label**	**Description of working posture**
D1	Preparation	No picture required.	
D2	Blow drying hair at the back of the head area	**Action Level (4/4)** 	Both upper arms are abducted 45 ° to 90 °, shoulder is raised, both wrists are bent also in extension and flexion as the action taken, right hand holds the dryer with shaking and left hand brushes hair, neck is slightly bent but trunk is rare bend, posture is mainly repeated more then 4 times per minute.
D3	Blow drying hair at fringe area	**Action Level (5/5)** 	Both upper arms are abducted 45 ° to 90 °, shoulder is raised, both wrists are bent also in extension and flexion as the action taken, right hand holds the dryer with shaking and left hand brushes hair, neck is slightly bent but trunk is rare bend, posture is mainly repeated more then 4 times per minute.
D4	Blow drying hair near the neck area	**Action Level (4/4)** 	Both upper arms are abducted 45 ° to 90 °, shoulder is raised, both wrists are bent also in extension and flexion as the action taken, right hand holds the dryer with shaking and left hand brushes hair with a brush, neck is slightly bent and trunk is bent, posture is mainly repeated more then 4 times per minute.
D5	Blow drying hair on both sides of the head area	**Action Level (4/3)** 	Both upper arms are abducted 45 ° to 90 °, shoulder is raised, both wrists are bent also in extension and flexion as the action taken, right hand holds the dryer with shaking and left hand stirs hair, neck and trunk are rare bent, posture is mainly repeated more then 4 times per minute.

Code	Actions	Static pictures and RULA action level (R/L) with the colour label	Description of working posture
D6	Blow drying hair on the top of the head area	Action Level (6/6) 	Both upper arms are abducted up to 90 ^{o}, shoulder is raised, both wrists are bent also in extension and flexion as the action taken, right hand holds the dryer with shaking and left hand brushes hair. Neck and trunk are bent; posture is mainly repeated more then 4 times per minute.

5.3.5 Rapid Upper Limb Assessment result

Based on the standard operation procedure (SOP) for RULA for hairdressing techniques, the static photos were taken from the video files. These static photos were then analyzed via web-based RULA. As a result, the action level of 21 working postures was summarized in Table 5.10, below.

Table 5.10. Summary of the action level of 21 working postures.

Code	Job description and associated working posture	Action level	
		Right	Left
A1	Starting to wash hair (dry to wet)	3	3
A2	Wash hair with both hands	3	3
A3	Washing hair with one of the hand	3	3
A4	Away from work	0	0
B1	Wet hair	0	0
B2	Apply shampoo	0	0
B3	Washing hair with one hand	5	5
B4	Wash hair with both hands	4	4
B5	Rinse	5	4
B6	Apply conditioner.	0	0
B7	Wash hair with both hands alternately	7	6
C1	Straightening in setting position	6	4
C2	Straightening in standing position (Back of the head area)	4	4
C3	Straightening in standing position (Top of the head area)	5	4
C4	Straightening at fringe area.	5	5
D1	Preparation	0	0
D2	Blow drying hair at the back of the head area	4	4
D3	Blow drying hair at fringe area	5	5
D4	Blow drying hair near the neck area	4	4
D5	Blow drying hair on both sides of the head area	4	3
D6	Blow drying hair on the top of the head area	6	6
		3.5	3.2

5.3.6. Critical analysis

In order to validate the results obtained from the questionnaire survey and to identify the risky postures adopted in hairdressing techniques, the action levels shown in Table 5.10 were further prioritized, as shown in Table 5.11.

Table 5.11. Critical analysis of the action level of 21 working postures *.

Code	Job description and associated working posture	Action Level		Critical rank
		Right	Left	
B7	Wash hair with both hands alternately	6	7	1
D6	Blow drying hair	6	6	2
C1	Straightening in sitting position.	6	4	3
B3	Washing hair with one hand	5	5	4
B5	Rinse in the washbasin area	5	4	5
C3	Straightening in standing position (Top of the head area)	5	4	6
C4	Straightening at fringe area.	5	5	7
D3	Blow drying hair at fringe area	5	5	8
B4	Wash hair with both hands	4	4	9
C2	Straightening in standing position (Back of the head area)	4	4	10
D2	Blow drying hair at the back of the head area	4	4	11
D4	Blow drying hair near the neck area	4	4	12
D5	Blow drying hair on both sides of the head area	4	3	13
A1	Starting to wash hair (dry to wet)	3	3	14
A2	Wash hair with both hands	3	3	15
A3	Washing hair with one hand	3	3	16
A4	Away from work	0	0	17
B1	Wet hair	0	0	18
B2	Apply shampoo	0	0	19
B6	Apply conditioner	0	0	20
D1	Preparation	0	0	21

* The rows coloured yellow represent the five most risky working postures.

As can be seen in Table 5.11, the risk of experiencing WMSDs with the right limb is greater than for the left limb except for hair-washing in the washbasin. This is because the right limb is functionally used to hold the device needed to complete the task, as in holding the straightening iron or blow-dryer.

Furthermore, three of the top scores are associated with hair-washing in the washbasin area (B7, B3 and B5), followed by hair-straightening (C1) and hair-blow-waving (D6). The result is similar to the questionnaire survey in which the most risky working postures identified were hair-washing, hair-straightening and hair-blow-waving.

5.4. Discussion

5.4.1. Introduction

This chapter has achieved its aim of validating the working postures involved in hairdressing and the relationships between the risk factors identified earlier in the research. Based on the observation with twelve professional hairdressers, 129 photos of risky working postures were taken for this research, 21 of these were retained as representative photos for the RULA analysis. These 21 identified representative working postures that appear during hairdressing techniques have been described and illustrated with different colour labels representing the associated critical level, e.g. the critical level 1 with a red colour label having the action level is ranked as 6 and above, which means that the associated working posture needs further investigation and changes may be required.

As a result, the risk of experiencing work-related musculoskeletal disorders with the right limb is greater than with the left limb. This is because the right limb is used to hold the tools needed to complete the task. Three out of the top critical overall scores associated with risky techniques are associated with hair washing in the washbasin area, followed by hair straightening and hair-blow-waving. The associated hairdressing techniques will be selected for further study in the following chapter.

5.4.2. Top critical working posture: hair-washing in the washbasin area

The most critical working posture was identified as hair-washing in the washbasin area, coded B7 (see Figure 5.6). As can be seen, the hairdresser's trunk and neck were bent forward, which, according to the evidence from the questionnaire, produces discomfort in the hairdresser's neck and lower back.

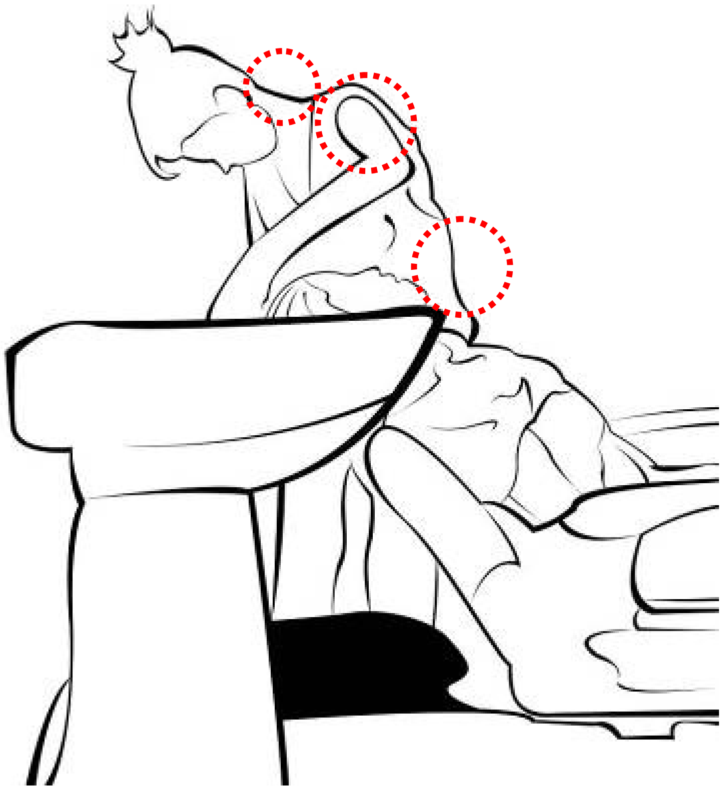

Figure 5.6. Hair-washing in the Washbasin area.

Nevala-Puranen *et al.* (1998) pointed out that if, during hair-washing, the hairdresser was to work behind the customer, support their body against the washbasin, use both hands, keep her arms near her body and relax her shoulders, then the musculoskeletal symptoms would decrease. This was confirmed by the questionnaire survey, which showed that low back pain among Taiwanese hairdressers is related to the working technique of hair-washing. In Figure 5.6, the three red dotted lines show that possible causes of discomfort are that the low back and neck were bent to the side, also the left upper arm abduction was a very great risky posture to attain during the task of washing a client's hair in the washbasin.

There are many ways to wash a client's hair in Taiwan and some of these might cause the discomfort in various body regions. Firstly, when standing in the styling chair area there are no arm supports for hair-washing (see coded A1 to A4 in Table 5.7); secondly, there may be a better position to support the arm if the hairdresser is standing behind the washbasin (see codes B3 to B5 in Table 5.8) then the elbows could have some rest and the body could be supported by being close to the basin during the hair-washing period. Finally, most harm (coded B7) was caused by standing at the side of the washbasin, where the lower back and neck were bent to the side; also the left upper arm was abducted to reach the client's hair.

5.4.3. Second critical working posture: hair blow-waving with a blow-dryer

The second most critical working posture involved the hairdressing technique coded D6 (Figure 5.7). This is hair blow-waving with a blow-dryer. From the observed posture, the dryer was held at a constant height with static muscles for an undesirable length of time, with bending and twisting the back to see the hair section and constant use of the pistol grip of the dryer. In addition, as can be seen in the red dotted line in Figure 5.7, the upper limb was raised between 60° to 90° or even over 90° for blow-drying the top of the head. Relevant research in Finland suggests that changing the height of the client's chair might decrease the extent of the motion in the shoulder, and the dryer should be held in the barrel area for a better position.

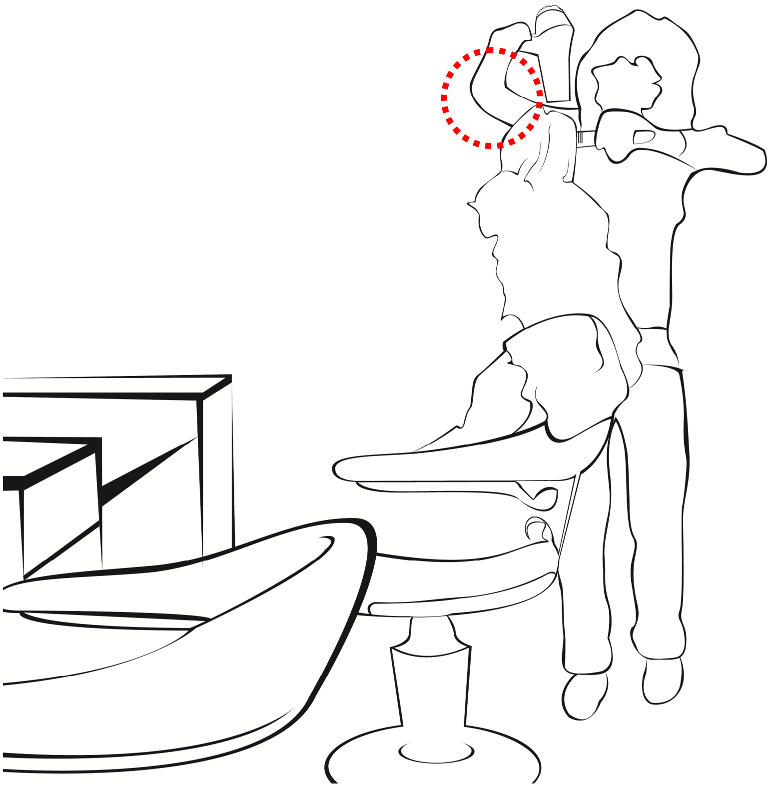

Figure 5.7. Hair blow-waving with a blow-dryer.

5.4.4. Third critical working posture: hair-straightening using a hair straightening iron

The third most critical working posture was identified as hair-straightening over the top of the head with a hair-straightening iron, coded C1 (see Figure 5.8). As a new technique for blow-drying, straightening irons are designed to temporarily straighten hair to produce straight or flattened results (Cutting and Rose, 2000). From the RULA analysis for the right limb, straightening hair in a sitting position came out as the third highest possible cause of discomfort in hairdressing techniques. In this technique, the straightening iron was held and gripped for a section of hair. In addition, as can seen in the red dotted line of Figure 5.8, the right upper limb was raised up to 90° for gripping section of hair on the top of the head.

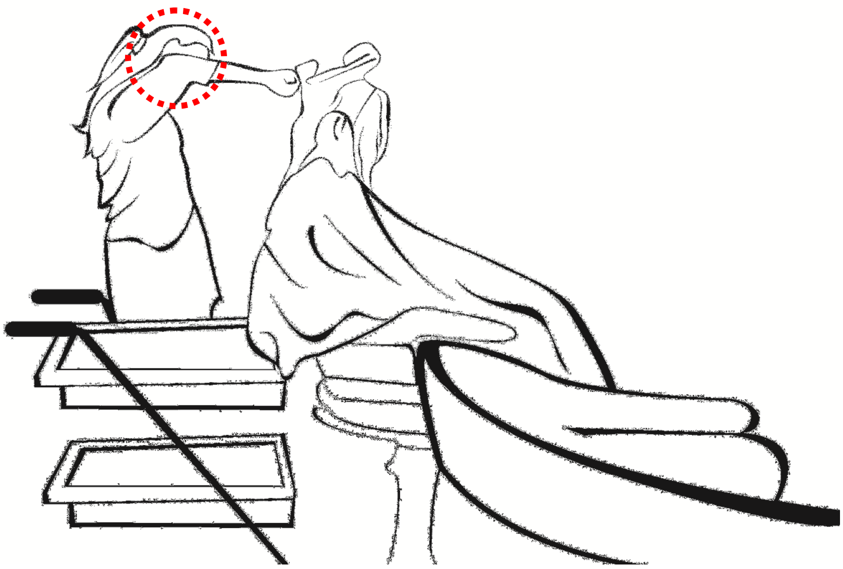

Figure 5.8. Hair-straightening with a hair-straightening iron.

5.5. Conclusions

This study validates the findings of the questionnaire survey, which highlights that hairdressing techniques of hair-washing in the washbasin area, hair-straightening and hair-blow-waving can cause the shoulder to be raised to fit the task on the top of the head with a large range of joint motions. The study also reveals that shoulder discomfort ranks second highest, which might be caused by the extreme working postures required to perform the associated techniques. This agrees with the results of the questionnaire survey.

As a recommendation for further study, hairdressers must have the autonomy and communication skills to continually improve job characteristics (i.e. administration and job description, etc.), working conditions (equipment and tools and environmental conditions etc.), and hairdressing techniques. Thus, an ergonomics training programme needs to be conducted to support the current system of hairdressing education in Taiwan. It is therefore recommended to further investigate the effect of the ergonomics training for WMSDs prevention. The hair blow-waving and hair-straightening are chosen for the study since they are manual tasks associated with the highest discomfort level in specific body regions.

It should be noted that hair-blow-drying can be improved by providing effective manual skill training, unlike hair-washing in which the discomfort may be linked to the physical design of the washing station, which is one of reasons that hair-washing was not chosen for the assessment of training effectiveness in the following study. Since the design of the washing station is an essential factor that causes discomfort in the lower back, further study of the ergonomics design of the washing station is required.

Chapter Six: Ergonomics Training Intervention for Risk Prevention in Hairdressing Working Postures

6.1. Introduction

6.1.1. Background

Despite a hairdresser typically spending long hours working on various daily techniques, such as cutting, blow-drying, perming and washing hair, little effort has been made to explore this might result in WMSDs (Fang *et al.*, 2007).

In 2005, Hairdressers Journal International (HJI, 2005) reported a new study by the Chartered Society of Physiotherapy which stated that nearly half a million workers in the UK had Repetitive Strain Injury (RSI) caused by their working conditions. The editor of Hairdressers Journal International also mentioned that RSI can be caused by a variety of factors including the fast pace of work, awkward posture and repetitive movements. Symptoms may include tingling, numbness, swelling in the hands, wrists, elbows, shoulders and neck. Moreover, evidence gathered over recent years shows that Upper Limb Disorders (ULDs) are not confined to any one particular group of workers or industrial activity, but are widespread in the workforce and have led to reports of high levels of arm pain, particularly from hairdressers (HSE, 2009).

For hairdressers, although direct observation and surface electromyography (sEMG) studies have been implemented to identify risk factors associated with work-related upper limb disorder (Veiersted *et al.*, 2008), there have been no studies establishing a normative database of 3D kinematic values for hairdressing techniques.

In the previous primary studies, various assessment tools had been chosen in order to expose the WMSDs found among professional hairdressers. It was proposed to start with the questionnaire survey and the observations recording the hairdressers' professional activities from their workplace as a pilot research in order to identify the hazards. The following assessment tools were integrated and used as the primary research methodology:

- Hairdresser-oriented musculoskeletal questionnaire: the hairdresser-oriented musculoskeletal questionnaire survey was conducted, based on the NMQ, and then developed. The NMQ has been modified and applied to other similar occupations, such as restaurant workers in Taiwan, by Chen *et al.* in 2003, and forestry workers in Finland, conducted by Miranda *et al.* in 2001 (Chapter 4).
- RULA: Rapid Upper Limb Assessment is a survey method developed for use in ergonomic investigations of workplaces where work-related upper limb disorders were recorded by McAtamney and Corlett in 1993. RULA was also developed through the evaluation of the postures adopted and muscle actions of professional hairdressers using a variety of hairdressing techniques where risk factors associated with upper limb disorders may be present (Chapter 5).

6.1.2. Motivation

The results of the hairdresser-oriented musculoskeletal questionnaire survey were published in the International Association of Societies of Design Research (IASDR) in 2007 (Fang *et al.*, 2007). The questionnaire survey showed that 91.7% of the participants reported shoulder discomfort as the most frequent problem (n=12). Thus, it is believed that work-related upper limb disorder is one of the major issues that impact on hairdressers' daily lives. Among these participants (n =12), discomfort was likely in the shoulder, lower back and right upper limb. Moreover, age, work experience, working hours and taking a break did not significantly affect the level of discomfort of the body regions ($p>0.05$). This study suggested that further quantitative research should be carried out to validate this result.

Following the questionnaire survey, a direct digital video recording was used to observe the twelve hairdressers. Based on the use of the revised Rapid Upper Limb Assessment analysis method, this study aimed to identify the risky techniques in terms of repetition, duration, force and awkward working posture. As a result, the most high-risk techniques were found to be hair-washing, blow-drying (hair blow-waving with a blow-dryer) and hair-straightening (straightened hair with a straightening iron). Furthermore, the body regions which displayed the most discomfort were the lower back, right upper limb and right shoulder. The study highlighted that awkward working postures during the hair blow-waving technique could lead to discomfort in the upper limb. Drying hair is the process of styling wet hair while blow-drying it (Palladino, 2003) with a hair dryer together with a variety of tools, including hands, combs and brushes, the choice of which depends on the style required (Woodhouse, 1996). Accurate measurement of upper limb movement during blow-waving techniques provides an objective measure of functional outcome and is valuable information for evaluation. Information about how healthy hairdressers perform the blow-waving technique and measurements of the upper limb joints angles required for these techniques enable the clinician to record and compare an awkward upper limb movement with normal movements.

Recently, participatory ergonomic intervention training conducted by St-Vincent *et al.* (2001) has demonstrated its effectiveness for the prevention of musculoskeletal disorders and for enhancing the autonomy of individuals performing both short-cycle repetitive tasks and long-cycle, non-repetitive, varied tasks. Moreover, it has less impact and bias from the culture and management of the organization where the participant works. Since hair-blow-waving and hair-straightening techniques are complex to observe, the effectiveness of a training programme might be difficult to measure based on direct observation or a qualitative questionnaire assessment.

In order to validate the effectiveness of the ergonomics training programme, the use of 3D motion analysis might be an alterative way to identify the awkward working postures objectively. With respect to awkward working postures, Pheasant (2006) pointed out that muscle is a tissue that responds badly to prolonged static mechanical loading. Static effort restricts the flow of blood to the muscle. The chemical balance within the muscle is disturbed, metabolic waste products accumulate and the condition of "muscular fatigue" supervenes. Typically, pain comes on after increasingly short periods of postural loading and rest is less certain to bring relief. At this point we are dealing not with discomfort but with physical injury and a disease process, which we refer to as work-related upper limb disorder, or repetitive strain injuries. Thus, there is a relation between awkward working posture, task cycle duration and the discomfort in specific body regions. For the measurement of the discomfort in the upper limb, an sEMG amplifier is commonly used for recording the electrical activity of the muscles of a participant's body regions during the working activities. However, the limitation of such a technique is that it requires specialists to place the inter-electrode on the surface of the appropriate muscle group in order to record electrode-to-electrode readings properly.

6.1.3. Aim and objectives

This study aims to implement 3D motion analysis and associated cycle task analysis to validate the effectiveness of the ergonomics training in the techniques of hair-blow-waving and hair-straightening, based on a comparison of pilot(pre)-test and evaluation(post)-test awkward movements. It is hoped that this study could facilitate the use of these 3D techniques to analyse processes in a hairdresser's technique.

In order to achieve this aim, the following objectives have been identified:

1. To arrange the testing apparatus of the laboratory of 3D motion capture in the Department of Occupational Therapy, National Cheng Kung University, Taiwan;
2. To conduct a pre-test in order to record the body movement associated with hair-blow-waving and hair-straightening techniques over the top of a manikin-head by 6 professional hairdressers (i.e. 3 were hair-blow-waving techniques and 3 were hair-straightening techniques) in the Department of Occupational Therapy, National Cheng Kung University, Taiwan;
3. To implement an ergonomics training programme within an academic semester (i.e. sixteen weeks) in the Department of Cosmetology and Styling, Tainan University of Technology for both lecturing and group training with participants;
4. To conduct a post-test in order to record the body movements of professional hairdressers;
5. To analyze the results and validate the effectiveness of the ergonomics training by comparing the differences between the pre- and post-tests in terms of right shoulder, right elbow, right wrist and the hip position based on the descriptive statistics, the Independent T test and the cycle graphic analysis.

6. To discuss the awkward postures involved in hair-blow-waving and hair-straightening techniques and to highlight the findings and limitations of this investigation and suggest future work that may be required.

6.1.4. Research limitations

Since hair-blow-waving and hair-straightening techniques have been identified by previous primary studies as the most risky hairdressing techniques that require urgent improvement, and the right hand is usually used to handle the hair-blow-dryer and hair-straightening iron, this study will mainly focus on the 3D motion analysis of the right upper limb. Nevertheless, the 3D motion analysis methods and associated analytical approach could be implemented for various techniques in the kinematic study of the upper limb.

Furthermore, 3D motion analysis offers the opportunity to reveal the relation between the motion of the upper extremity and the risk of experiencing work-related injuries. In 2006, Faupin *et al.* (2006) studied the relation between the range of upper extremity motions and the key risk factors for joint pain, as in hand-bike propulsion, with the help of a 3D movement analysis. They revealed that the high amplitudes and fast angular joint accelerations of the upper limb could result in overuse injuries. Because the study of joint peak angle and joint acceleration belong to human movement science, the acceleration of the upper limb and peak angle in relation to the discomfort level in various body regions is excluded from the analysis and is therefore suggested as a topic for further study.

Moreover, the reason to study hairdressing techniques on the top of the static manikin-head is because it can avoid the head movement and eliminate the process bias caused by human error. Furthermore, hairdressing activities performed on the top of the manikin-head normally require risky shoulder ROMs which depart from the neutral posture.

Furthermore, the raw data of the 3D kinematics values used in this study could be blocked by the manikin-head and left arm, which causes sudden shifts. Although the advanced filtering algorithm for the statistical smoothness characteristics of the camera data has a built-in assumption that a human movement trajectory should not contain any sudden shifts, He and Tian (1998) have stated that the human operator's judgment is still required in such cases and remains the ultimate solution for removing outliers. Since this study aims to use 3D motion capture to study the 3D upper limb motion for hairdressers based on a quantitative method, the raw data of the 3D kinematics values with sudden shifts will be excluded from the study. Nevertheless, each marker can be uniquely and accurately tracked, eliminating the error at its source.

6.2 Training Intervention Programme

6.2.1. Introduction

Hairdressers suffer musculoskeletal discomfort, injury and harm, which means not only decreased job performance and lower productivity, but also increased time off work and early retirement from this profession (Fang *et al*., 2007; Wu *et al*., 2004; Chuang, 2005). There are various forms of discomfort in body regions discovered from the research findings, however, as hairdressers work in different ways and use different techniques, how to decrease this discomfort whilst at the same time identifying the most important points to improve the posture and movement of their techniques without detriment to the look of the hairstyle is an important problem. From this point of view, the strategy of improvement in ergonomic knowledge and evaluation of training effectiveness will make a contribution to this industry.

Based on the previous studies, the awkward posture and body motion lead to local mechanical stress on the muscles, ligaments and joints, resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system, in turn cumulatively generating discomfort in particular body regions.

For a researcher, the goal is to turn the theory of the assessment of exposure to risk of WMSDs in hairdressing techniques into suitable, practical, assessment methods. However, it is also important to explain the causes of discomfort to hairdressers, especially those who are unfamiliar with ergonomic knowledge. In this research, the use of observation and sEMG as risk assessment methods was considered since they have been typically used for the study of hairdressing work in recent studies. However, hairdressers' needs might be completely different or they might misunderstand the ergonomists' intervention. Such confusions need to be considered in the future development of the exposure assessment methods that are able to combine the different points of view.

In order to provide a better understanding of the causal relationship between posture, technique and discomfort, 3D motion analysis will be used to reveal the relationships between the joint ROMs and the risky hairdressing techniques that are associated with awkward working postures that can lead to the development of discomfort in some body regions. Furthermore, this study will implement the task cycle graph, which helps to illustrate and identify the awkward postures. Through the use of the task cycle graph, the change in the body movement over the normalized task cycle duration can be seen clearly.

Thus, a training intervention programme will be conducted to educate hairdressers about how to maintain and minimize joint angles of the upper limbs to approach a more neutral posture during the performance of the high-risk techniques and working postures was established.

The programme will consist of four parts: the pre-test (week 1), the two-day lecture (weeks 2 and 3, 2 hours each day), and the group study (weeks 4 to 15, 2 hours of each day) and the evaluation test (week 16). Both the lecture and the group study are described in the following sections.

6.2.2. Lecture

The lecture programme lasted two days over a two-week period, using PowerPoint slides and handouts. It aimed to promote understanding that the prevention of work-related upper limb disorders could be achieved by improving the joint angles of the shoulders, elbows, wrists and hips for both the right and left upper limbs, so that a more neutral posture could be used, during the performance of the high-risk techniques and working postures. The objectives were:

1. To introduce the basic occupational ergonomic knowledge (week 1);
2. To emphasize the relationship of joint angles with work-related upper limb disorders (week 1);
3. To demonstrate the high-risk techniques and working postures based on the earlier study using Rapid Upper Limb Assessment techniques (week 1);
4. To introduce the new handling technique for the improvement of the risky working postures often found in hair-blow-waving and hair-straightening techniques (week 1);
5. To introduce the group study for establishing the self-awareness of work-related upper limb disorders (week 2).

6.2.3. Group study

Based on ergonomic work techniques recommended for hair-washing, cutting, rolling and blow-drying (Nevala-Puranen *et al.,* 1998), this study firstly aimed to train hairdressers to adopt the new manual handling technique (Figure 6.2) instead of the conventional one (Figure 6.1) for the functional blow-waving activity. Secondly, it aimed to emphasise the ergonomic knowledge about the operation procedure of handling a hair-straightening iron (see Figure 6.3), and thirdly to reduce the cycle time spent on the practice.

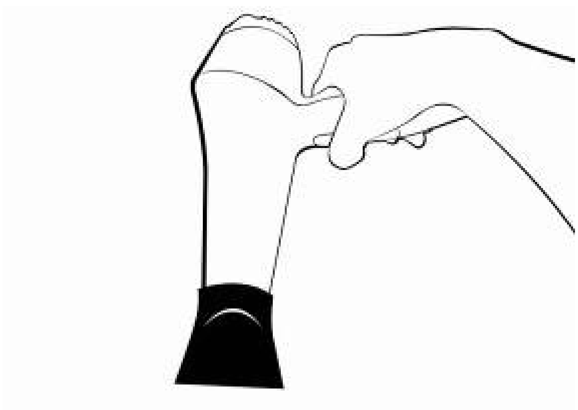

Figure 6.1. Conventional manual handling techniques increase the discomfort in the right arm, in particular for the shoulder and wrist.

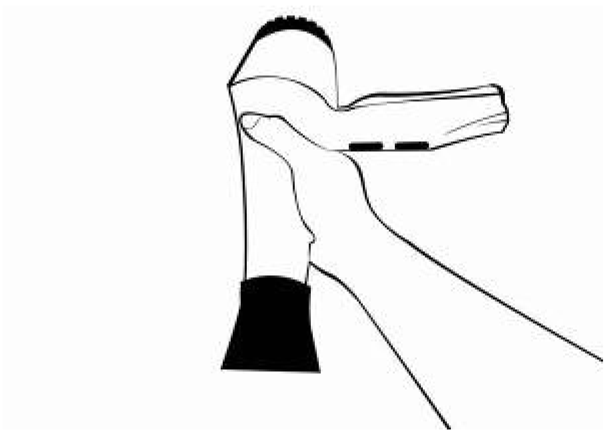

Figure 6.2. New manual handling techniques could reduce the discomfort in the right arm, in particular for the shoulder and wrist.

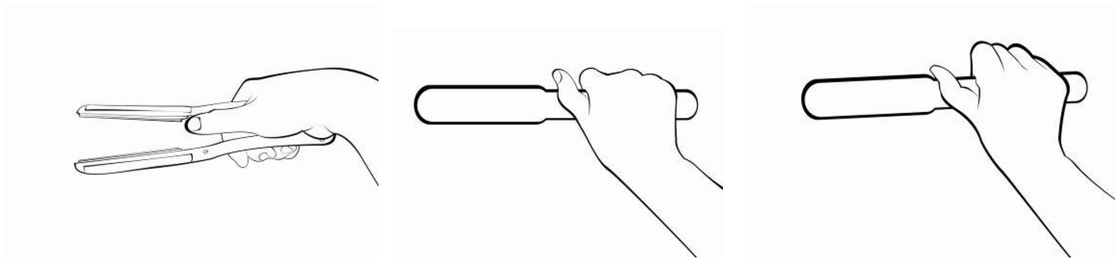

Figure 6.3. The above three steps (from left to right) represent the technique to handle a hair-straightening iron during the functional hair-straightening activity.

In order to practise the new technique and to establish a self-awareness of work-related upper limb disorders, a twelve-day group-study over a 12-week period took place**.** During the day, the participants were divided into two groups for practice and discussion since all of them needed to practise the selected hairdressing techniques and associated working postures based on the following procedure:

- **Practise and identify problem working postures involved in hairdressing techniques:** For each group, one participant was asked to practise the selected risky hairdressing techniques using a manikin-head, and the rest of the participants were asked to identify the risky working postures;
- **Group discussion to propose solutions**: After the selected group member had finished the practice, all of them discussed the risky working postures identified and proposed solutions. This same procedure was implemented repetitively until all participants had practised the same selected working postures for hairdressing techniques;
- **Training Intervention**: During the group study, the experimenter interrupted the practice and discussion only when the participants called for help.

6.3. Trial Protocol

6.3.1. Participant selection criteria

Six professional hairdressers were invited for this ergonomics training intervention including lecturing and training procedures in the Department of Cosmetology and Styling, Tainan University of Technology. Three hairdressers were invited to join the hair-blow-waving technique training programme, and another three hairdressers were invited to join the hair-straightening technique training programme. All participants met the following selection criteria:

- Over 18 years old;
- Over one-year of work experience as a full-time hairdresser.

6.3.2. Testing apparatus

A six-camera, 3D-motion analysis system (Motion Analysis Corporation, Santa Rosa CA) was used to capture kinematic data at 100Hz. Twenty retro-reflective markers (1”-diameter) were attached to the participant over pilot-determined bony landmarks on the trunk and upper extremities where subcutaneous tissue was thin and relatively fixed to the underlying skeleton (see Figure 6.4).

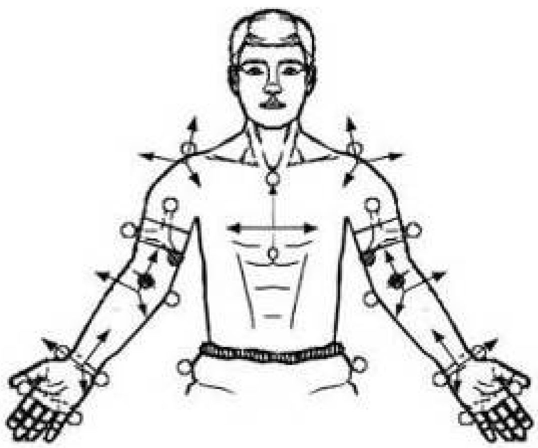

Figure 6.4. Illustration of marker placement for the upper extremity model.

Each joint angle consists of x, y and z directions. Since the angles of each direction could be positive or negative, the terms associated with the positive and negative angles of each direction need to be defined, as below:

- X direction (sagittal plane, see Figure 6.5): flexion (-) / extension (+)
- Y direction (frontal plane, see Figure 6.5): abduction (-) / adduction (+)
- Z direction (transverse plane, see Figure 6.5): external rotation (-) / internal rotation (+)

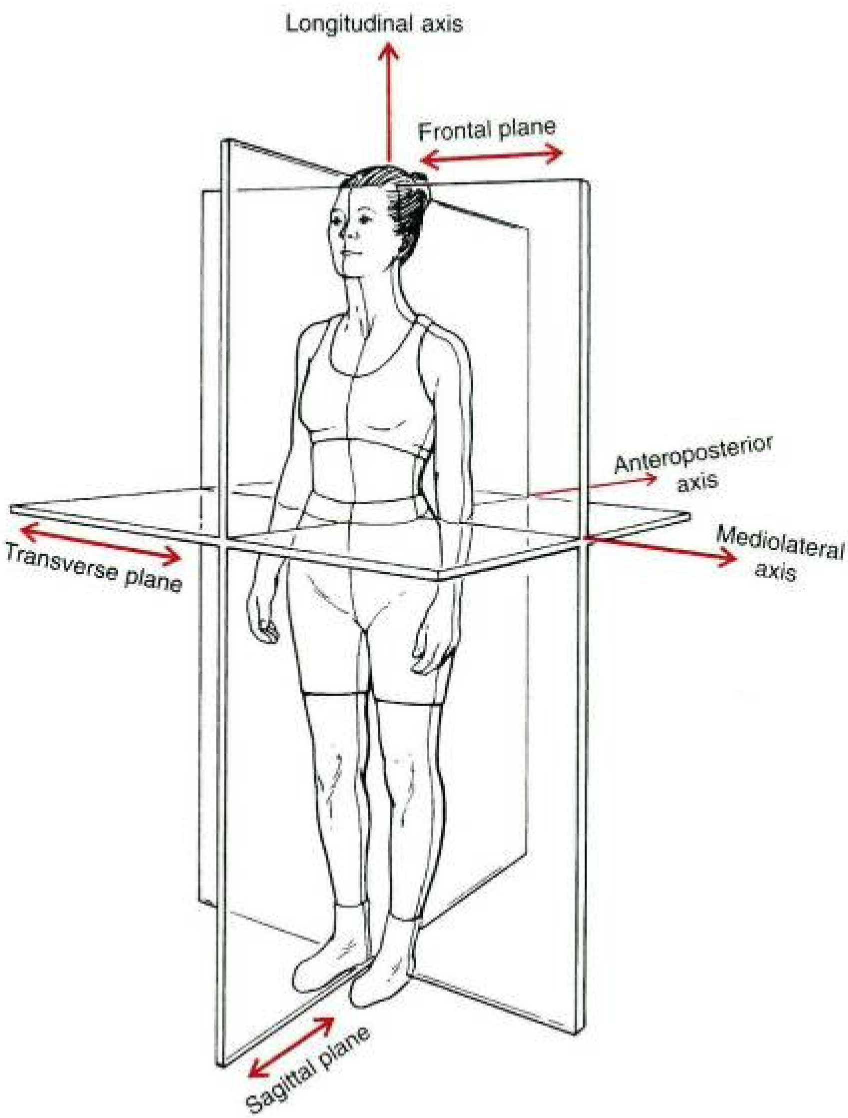

Figure 6.5. Planes and axes on the human body (Hamill and Knutzen, 2003)

A two-segment biomechanical model was used to calculate right upper-extremity motions, which involve the right upper arm and right lower arm. Sequential angular displacements for each joint were calculated using the sequence of flexion-abduction-external rotation. The joint motions were right shoulder flexion, right shoulder abduction, right shoulder external rotation (medial rotation), right elbow flexion, right elbow abduction and right elbow external rotation (forearm pronation). Shoulder motion was described by the humerus relative the trunk, and trunk motion was calculated relative to the fixed coordinate system of the laboratory.

6.3.3. Experimental procedure

As can be seen in Figure 6.6, the experimental framework consists of four parts implemented step-by-step, these are the pre-test, the lecture, the group study and the evaluation test.

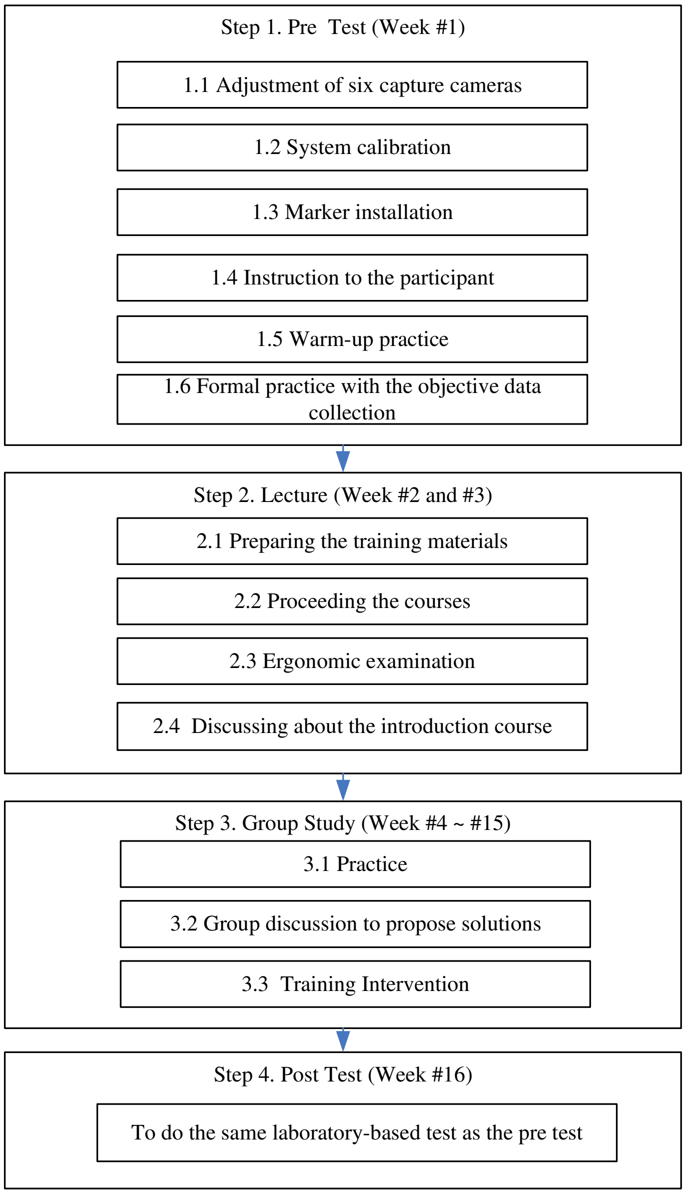

Figure 6.6. Experimental procedure for the ergonomics training intervention programme.

The timetable was as follows:

- To conduct the pre-test (week 1);
- To implement the lecture (weeks 2 to 3);
- To implement the group study (weeks 4 to 15);
- To conduct the post-test (week 16).

Therefore, by comparing the difference between the selected joint angles in pre-test and post-test, it was hoped to validate the effectiveness of the proposed programme for the reduction of the risky joint angles to approach the neutral posture among this group of six professional hairdressers.

During the pilot- and post-tests, in order to reduce the process bias, the standard operation procedure (SOP) was as described in the following section for all participants.

6.3.4. Standard Operation Procedure (SOP) for the Pre and post-training tests

During the pilot- and post-tests, in order to reduce the process bias, the standard operation procedure (SOP) was followed for all participants. There were five sections in the experiment, shown in Figure 6.7. In this study, the laboratory supported the personnel and ergonomists who could set the system up by, for example, adjusting the capture cameras to fit the location of the hairdressing performance area, calibrating the system, helping to stick the markers in position, helping with the data collection and any technical problem-solving.

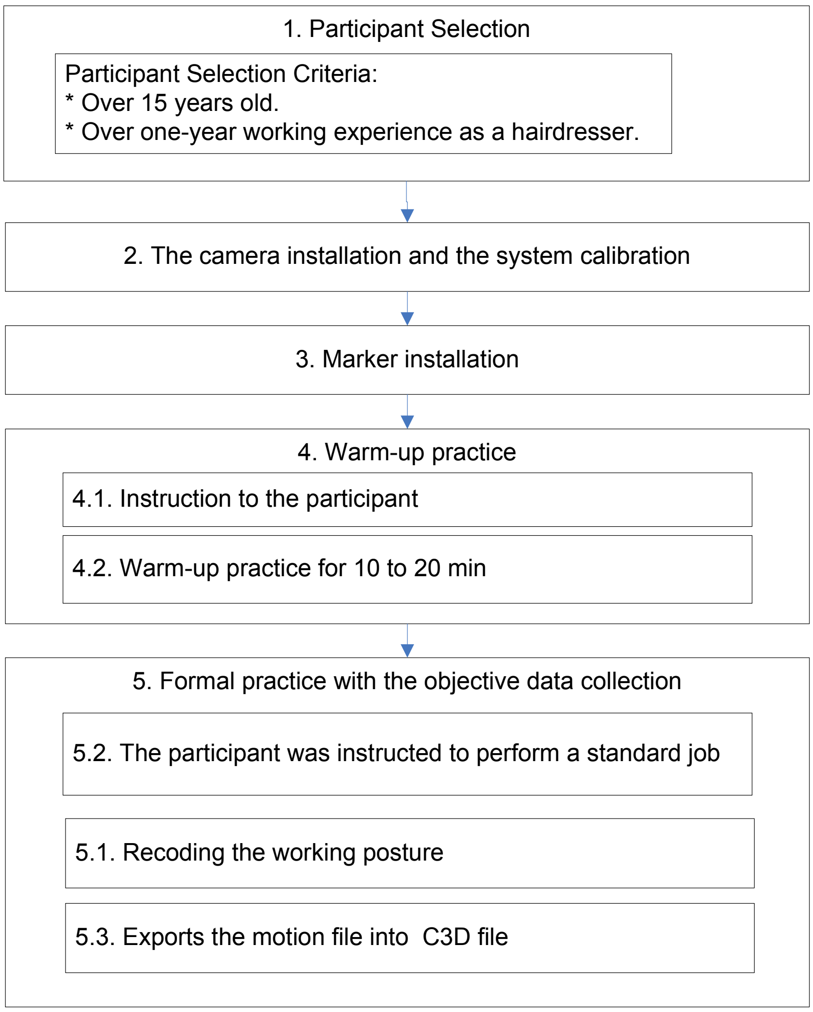

Figure 6.7. Standard operation procedure (SOP) used in Chapter 6.

In stage 1, six professional Taiwanese hairdressers, who met the selection criteria, volunteered to join this study. In stage 2, at the beginning of pre- and post-tests, the capture cameras were adjusted to fit the location of the hairdressing performance area as shown in Figure 6.8.

Figure 6.8. The motion system was calibrated.

In stage 3, twenty retro-reflective markers were attached to the upper limb and lower back area of each participant. In stage 4, the experimenter introduced the SOP to participants. The participants were instructed to practise a standard hairdressing task for 10 minutes.

In stage 5, the participants were instructed to perform the standard task using the techniques as follows: At the beginning of the formal practice, the starting position for the kinematic study was defined as standing comfortably, arms at sides, with forearms naturally rotated in a relaxed posture (pronation). After that, the participants were asked to perform the simulated working postures from the start position, and to return their arms to their sides after achieving the desired movement. They performed the working postures at a self-selected speed. Joint position values were recorded during the entire movement sequence of each working posture. The transition from rest to activity was repeated for four blocks.

During the performance of each working posture, tracking software - Qualisys Track Manager (QTM) - was used to create a C3D data file (see Figures 6.9. and 6.10.). Since the C3D file is in the .txt format, it can be imported into the statistical analysis tools e.g. EXCEL™ and SPSS.

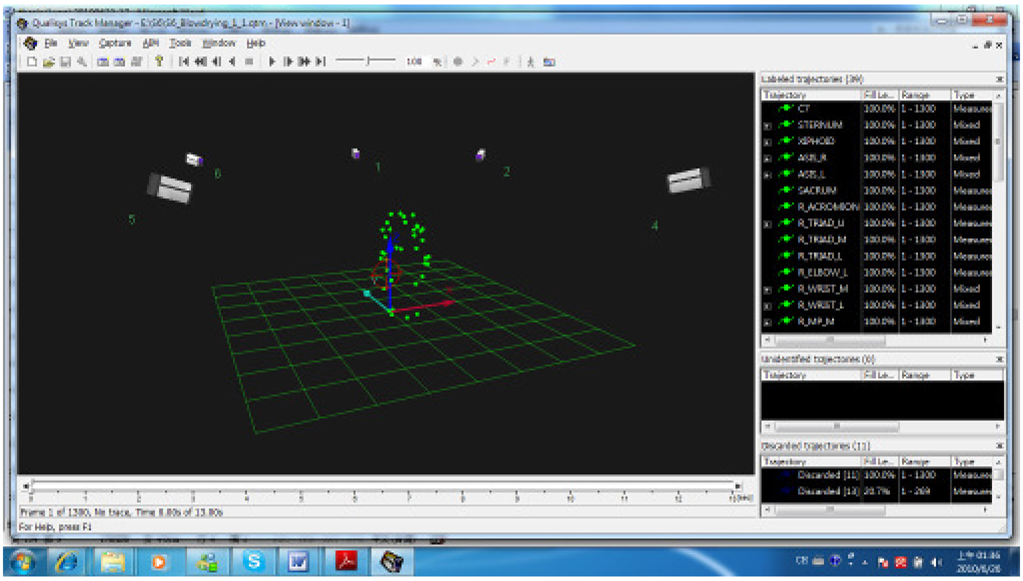

Figure 6.9. User interface of Qualisys Track Manager.

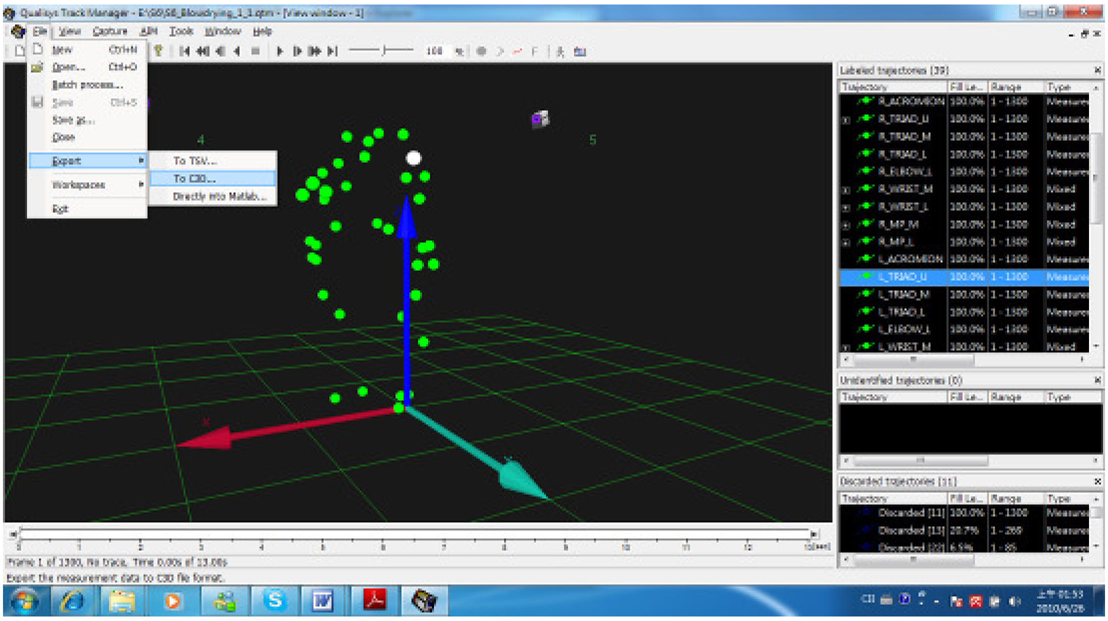

Figure 6.10. Qualisys Track Manager can be used to export the motion data into C3D file in .txt format.

In total, it took approximately four hours for participants to complete an experiment for each working posture; this is because they were asked to perform the simulated working posture movement four times, and had 10-minute breaks between blocks. Although this was time-consuming, the objective data collected accurately represented the joint angles on a real-time basis in three dimensions since the objective data collected had an accuracy based on a calibration of 1/1M° of angle. Because each angle represents a 3D direction, the data can be played back using the 3D skeleton animation software, which further explains the body movement.

6.4. Analysis

6.4.1. Data Adjustment

The 3D kinematic data captured from the six-camera 3D motion analysis system are recorded into a time-sequence database with the joint angle value. These data sets are saved into a text file (see Figure 6.11.), which can then be imported into EXCEL™ and SPSS for further analysis. It is observed that error trails at the beginning and end of the experiment appear to be zero degrees, thus the error trails for which the joint angle is equal to zero degrees were excluded from the analysis.

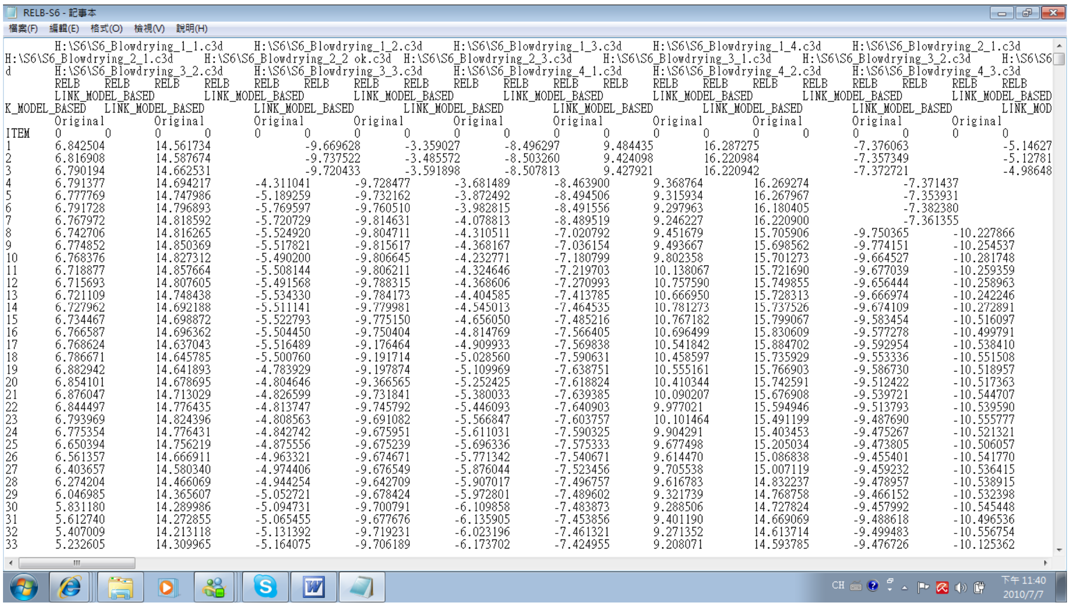

Figure 6.11. C3D file in .txt format.

Since different participants performed the specific hairdressing techniques at their preferred pace, the time spent on each data set might be varied differently to the individual skill/technique difference. Thus, each data set has a different total record number (n), which needs to be calibrated into the same time-sequence as a percentage, namely the Cycle Task Analysis. For instance, as can be seen in Table 6.1, two data sets have a different sample size: the sample size of the first data set is N=20, and of the second data set is N=10. Since the sequence number (SN) of both data records is different, it is not possible to make a comparison of the difference of the working posture (i.e. joint angle) between the two data sets.

Table 6.1. An sample showing two data sets having different sample sizes.

The first data set (N=20)		The second data set (N=10)	
Sequence number (SN)	The joint angle (degree)	**Sequence number (SN)**	The joint angle (degree)
1	0	1	0
2	10	2	10
3	12	3	27
4	14	4	30
5	16	5	45
6	20	6	50
7	22	7	30
8	25	8	20
9	27	9	10
10	30	10	0
11	30		
12	28		
13	25		
14	22		
15	21		
16	20		
17	18		
18	15		
19	10		
20	0		

In order to compare the motion difference of the two data sets, it is necessary to implement the task cycle analysis on the data sets, described as follows. As can be seen in Table 6.2, the cycle task time (CT) of each data record can be obtained by the data sequence number (SN) of each data record divided by the sample size (N), i.e. the cycle task time CT = (SN÷N) × 100. Thus, the following two data sets have a different sequence number of data records but have the same task cycle time, which allows the comparison of the difference of the working posture (i.e. joint angle) between the two data sets to be made in terms of the same task cycle time.

Table 6.2. A sample showing how to calculate the cycle task time CT = (SN÷N) × 100.

The first data set (N=20)			The second data set (N=10)		
Sequence number (SN)	**Task Cycle (CT)(%)**	The joint angle (degrees)	Sequence number (SN)	**Task Cycle (CT)(%)**	The joint angle (degrees)
1	5	0	1	5	0
2	10	10		10	
3	15	12	2	15	10
4	20	14		20	
5	25	16	3	25	27
6	30	20		30	
7	35	22	4	35	30
8	40	25		40	
9	45	27	5	45	45
10	50	30		50	
11	55	30	6	55	50
12	60	28		60	
13	65	25	7	65	30
14	70	22		70	
15	75	21	8	75	20
16	80	20		80	
17	85	18	9	85	10
18	90	15		90	
19	95	10	10	95	0
20	100	0		100	

6.4.2. Participant information

Three professional hairdressers (i.e. all females, aged 20-25 years, with 2~8 years work experience.) completed the study for the hair-blow-waving technique, and another three professional hairdressers (i.e. one male, two females, aged 21-27 years, with 2~6 years work experience.) completed the study for the hair-straightening task. Participants had no orthopaedic or neurological conditions and no upper extremity limitations. They were asked to perform the four simulated tasks from the start position and to return their arms to their sides after achieving the desired movement.

6.4.3. Descriptive statistics

The descriptive statistics aim to examine the effectiveness of the ergonomics training programme for risk prevention involving the range of motion of the four joints (ROMs) affected by the right upper limb: the shoulder, elbow, wrist and hip. Each joint ROM has three modes of operation: flexion, abduction and external rotation. The Independent T test was performed on the motion data of the pre- and post-test. A p-value of less than 0.05 was considered significant with a level of significance of $\alpha = 0.05$.

With regard to the relationship between the joint ROM and discomfort: when the angle ROM of the shoulder and wrist approaches the neutral posture, discomfort during the functional task can be reduced. This differs from the situation for the elbow where a joint ROM approaching 90^{o} means a reduction in discomfort and a value approaching the neutral posture means increased discomfort (Petuskey *et al.*, 2007). The followings statistical analysis represents the effectiveness of the training in terms of the improvement of joint ROMs during the functional hair-blow-waving and hair-straightening techniques.

(1) Hair-blow-waving

With respects to the hair-blow-waving technique, as can be seen in Table 6.3, the analysis indicates the success of the training programme since 80% of the directional joint ROMs were improved significantly. Furthermore, since the programme was not designed to improve the hip ROMs, the result indicates that there was only a slight change in the hip ROMs of around 1^{o}~2^{o}.

Table 6.3. Statistical analysis on the effectiveness of the training in terms of the improvement of Joint ROMs during the functional hair-blow-waving techniques.

Joint ROMs	Direct*	Improvement*	Rank
Shoulder	Flex/Ext	-17^{o}	1
Shoulder	Ext/Int Rota	-9^{o}	2
Shoulder	Abd/Abb	-2^{o}	3
Wrist	Abd/Abb	-2^{o}	4
Hip	Flex/Ext	1^{o}	5
Hip	Ext/Int Rota	1^{o}	6
Hip	Abd/Abb	2^{o}	7
Wrist	Flex/Ext	3^{o}	8
Elbow**	Flex/Ext	-11^{o}	9
Elbow	Pronation/Supination (palm up)	$+21^{o}$	10

* The red coloured figures means no training effectiveness and the figure coloured blue means that the training was effective or lessened the discomfort level in the specific body region.

** The elbow flexion approaching 90° could reduce the discomfort level, which differs from the other joint ROMs where an increased joint angle means increasing the discomfort (Petuskey *et al.*, 2007). In this case, the elbow flexion is decreased by 11^{o}, which means an increased discomfort level. This is caused by a very large standard deviation, which will be further explained in the following section.

As can be seen in Table 6.3, the programme was most effective when improving the reduction of the flexion/extension angle of the right shoulder (-17°) and of the internal/external rotation angle (-9°). However, the programme seems to increase the pronation/supination angle of the elbow (+21°) and decrease the flexion/extension angle of the elbow (+11°), thus the programme could increase the discomfort level in the elbow. However, a large standard deviation is found in the data sets for the pronation/supination of the elbow, which will be further analyzed by manual calibration (He and Tian, 1998). This will be mentioned in the Discussion section below.

(2) Hair-straightening

As can be seen in Table 6.4, the analysis of the result indicates the success of the programme for hair-straightening techniques since 90% of the directional joint ROMs involved with the activity of hair-straightening were improved significantly. The programme was most effective in reducing the internal/external rotation of the shoulder (-26°), followed by the flexion/extension angle of the elbow (+11°) and the pronation/supination angle of the elbow (-9°). However, it had the effect of increasing the abduction/adduction angle of the elbow (+14°). Furthermore, similar to the hair-blow-waving technique, the programme did not aim to improve the hip ROMs, and indeed only a slight change in the hip ROMs of 0^{o} ~1^{o} occurred.

Table 6.4. Statistical analysis of the effectiveness of the training in terms of the improvement of Joint ROMs during the functional hair-straightening technique.

Joint ROMs	Direct*	Improvement *	Rank
Shoulder	Ext/Int Rota	-26°	1
Elbow**	Flex/Ext	+11°	2
Elbow	Pronation/Supination (palm up)	-9°	3
Wrist	Flex/Ext	-5°	4
Shoulder	Flex/Ext	0°	5
Hip	Flex/Ext	0°	6
Hip	Abd/Abb	0°	7
Hip	Ext/Int Rota	+1°	8
Wrist	Abd/Abb	+2°	9
Shoulder	Abd/Abb	+14°	10

* The figures coloured red indicate no training effectiveness and the figure coloured blue mean that training was effective or lessened the impact of the discomfort in a specific body region.

** The elbow flexion approaching 90^{0} could reduce the discomfort level, which differs to other joint ROMs where an increased joint angle means increasing the discomfort (Petuskey *et al.*, 2007). In this case, the elbow flexion is increased by 11^{0}, which means a reduction in the discomfort level, thus validating the effectiveness of the training.

Although it also impacted on the flexion/extension angle of the elbow (+2°) and the flexion/extension angle of the wrist (+1°), this can be ignored since the impact approaches zero.

6.4.4. Validity study (Hair-blow-waving)

The aim of the validity study is to confirm the training effectiveness based on the Independent T Test and to confirm the feasibility of the task cycle graph/analysis used to demonstrate the difference of the specific body movement between the pre-test and post-test. As can be seen in Table 6.5, the Independent T Test is used to examine the significance of the difference between the pre- and post-tests.

Table 6.5. The summary of the result of Independent T Test of the joint activity of hair-blow-waving.

Joint ROMs	Direction	Degree (°)			Significance
		Pilot Test	Evaluation Test	Improvement*	
Shoulder	Flex/Ext	-24	-8	-17	p<0.01
Shoulder	Ext/Int Rota	19	10	-9	p<0.01
Shoulder	Abd/Abb	33	31	-2	p<0.01
Elbow	Flex/Ext	-67	-56	-11**	p<0.01
Elbow	Pronation/Supination(palm up)	-42	-63	21	p<0.01
Wrist	Flex/Ext	-1	4	3	p<0.01
Wrist	Abd/Abb	-16	-14	-2	p<0.01
Hip	Flex/Ext	-4	-5	1	p<0.01
Hip	Ext/Int Rota	1	2	1	p<0.01
Hip	Abd/Abb	1	2	2	p<0.01

* A negative value means that the ergonomics training programme has the benefit of improving a risky joint ROM. Conversely, a positive value means that the ergonomics training programme has had the effect of improving a risky joint ROM.

** The elbow flexion approaches to 90° and could reduce the discomfort level, which differs from the other joint ROMs where an increased joint angle mean increasing the discomfort. In this case, the elbow flexion is decreased by 11°, which means increasing the discomfort level, even though a very large standard deviation is observed over the raw data. This will be further explained in the following section.

The detailed analysis and associated description of the specific body movement is summarized in the following sections. The composite graphs, known as the task cycle analysis, will be used to demonstrate the movement of a joint during each task. In the task cycle analysis, the joint movement involved in the functional work of the task was normalized for task cycle duration and included a ±1 standard deviation band.

(1) Right shoulder flexion

As can be seen in Table 6.5, the mean of the right shoulder flexion movement is -24° ± 24 in the pilot test and the size of the sample was n = 20,201. As for the evaluation test, the mean of the right shoulder flexion movement is -8° ± 28 for a sample size of n = 13,800.

As can be seen in Table 6.6, the descriptive statistical analysis indicates that the right shoulder flexion is reduced by 6°. After that, the Independent T Test was applied to the raw data to examine the significance of the difference. As a result, it indicates that the difference in the mean right shoulder flexion between the pilot and the evaluation tests is significant ($p<0.01$). Therefore, the ergonomics training programme is effective and can adjust the right shoulder flexion to approach the neutral posture during the functional hair-blow-waving technique, which in turn reduces the risk of experiencing work-related musculoskeletal disorders.

Table 6.6. Pre- and post-test analysis of the directional angles of right shoulder flexion during the functional work involving the hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pilot test	20,201	-24°	24	p<0.01
Evaluation test	13,800	-8°	28	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference. It is the reason for using the task cycle duration instead of the time-based sequence for the comparison of the difference of the motion between of the pilot and evaluation tests.

As can be seen in Figure 6.12, the task cycle graph represents the entire hair-blow-waving technique at the right shoulder flexion. The blue line represents the right shoulder flexion in the pilot test, and the green line represents the evaluation test values. It is obvious that the overall right shoulder flexion after the ergonomics training is reduced.

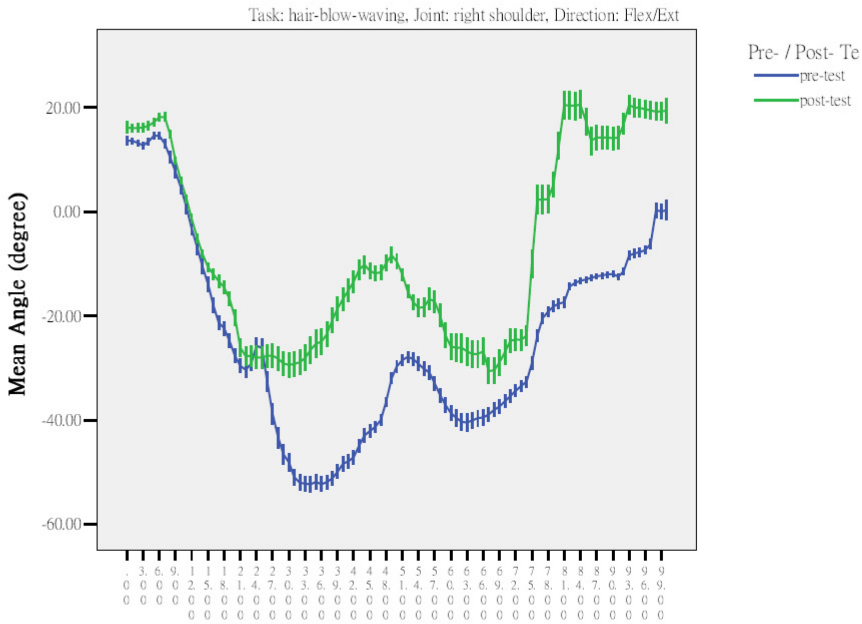

Figure 6.12. Graph of right shoulder flexion during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(2) Right shoulder abduction

As can be seen in Table 6.7, the mean of the right shoulder abduction movement is 33° ± 22 in the pilot test for a sample size of n = 16,300. As for the evaluation test, the mean of the right shoulder abduction movement is 31°± 24 for a sample size of n = 10,200.

As can be seen in Table 6.7, the descriptive statistical analysis indicates that the right shoulder abduction is reduced by 2°. Next, the Independent T Test was applied to the raw data to examine the significance of the difference. This indicates that the difference of the mean right shoulder abduction between the pre- and post-tests is significant ($p<0.01$). Therefore, the ergonomics training programme is effective and can adjust the right shoulder abduction to approach the neutral posture during the functional hair-blow-waving technique, which in turn reduces the risk of experiencing WMSDs.

Table 6.7. Pre- and post-test analysis of the directional angles of right shoulder abduction during the functional work involved in a hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pilot test	16,300	33°	22	p<0.01
Evaluation test	10,200	31°	24	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Figure 6.13 shows the task cycle graph representing the entire hair-blow-waving technique at the right shoulder flexion. The blue line represents the right shoulder abduction in the pilot test, and the green line represents the evaluation test values. It is clear that the overall right shoulder abduction is reduced after the ergonomics training.

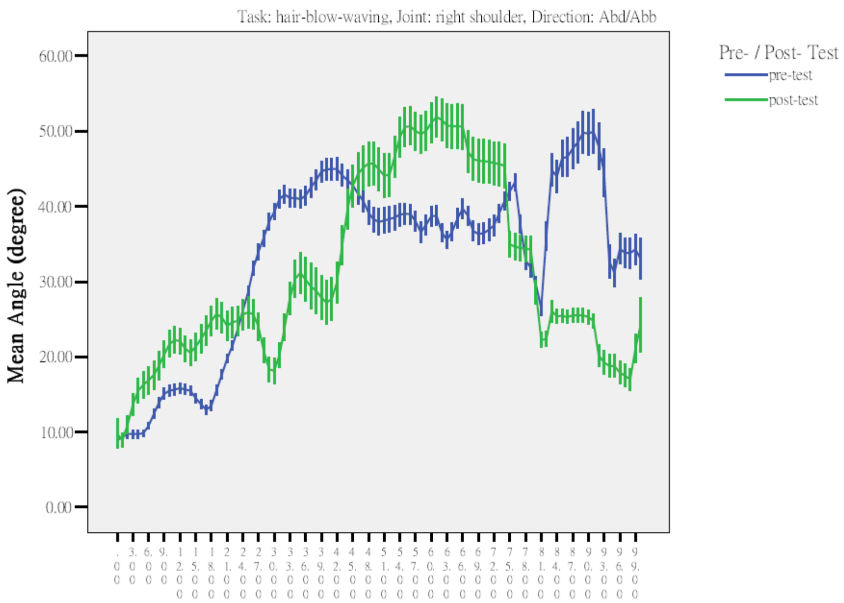

Figure 6.13. Graph of right shoulder abduction during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(3) Right shoulder external rotation

As can be seen in Table 6.8, the mean of the right shoulder external rotation movement is 19° ± 20 in the pilot test for a sample size of n = 13,192. As for the evaluation test, the mean of the right shoulder external rotation movement is 10° ± 9 for a sample size of n = 3,985.

As can be seen in Table 6.8, the descriptive statistical analysis indicates that the right shoulder external rotation is reduced by 9°. The Independent T Test was then applied to the raw data to examine the significance of the difference. The result indicates that the difference of the mean right shoulder external rotation between the pre- and post-tests is significant ($p<0.01$). Therefore, the ergonomics training programme is effective in that it can adjust the right shoulder external rotation to approach the neutral posture during the functional hair-blow-waving technique, which in turn reduces the risk of experiencing work-related musculoskeletal disorders.

Table 6.8. Pre- and post-test analysis of the directional angles of right shoulder external rotation during functional work involving the hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	13,192	19°	20	p<0.01
Post-test	3,985	10°	9	

*Since different participants performed the specific hairdressing techniques **for** four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Figure 6.14 is the task cycle graph representing the entire hair-blow-waving technique at the right shoulder external rotation. The blue line represents the right shoulder external rotation in the pre-test, and the green line represents the post-test values. It is clear that the overall right shoulder external rotation is reduced after the ergonomics training.

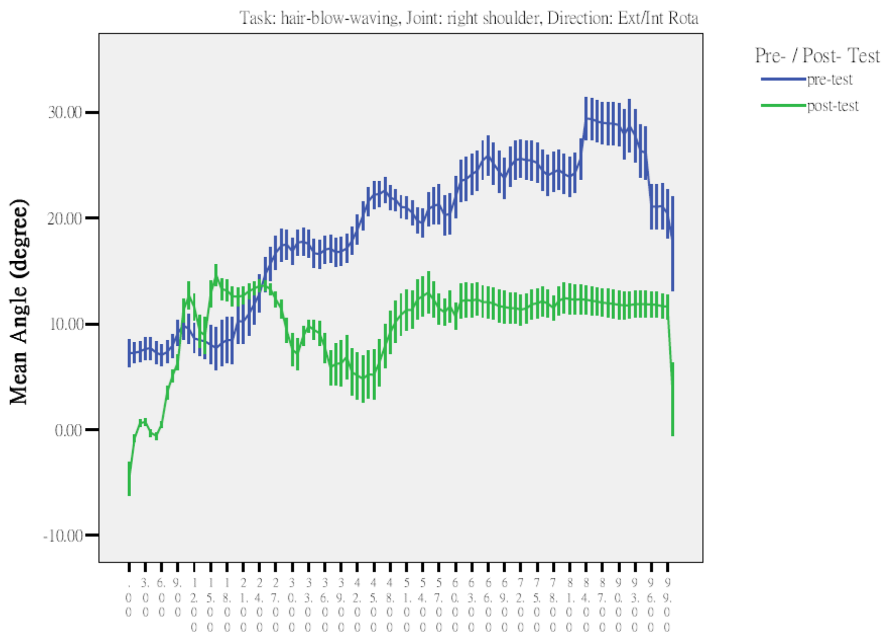

Figure 6.14. Graph of right shoulder external rotation during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(4) Right elbow flexion

As can be seen in Table 6.9, the mean of the right elbow flexion movement for the pre-test is -67° ± 35 for a sample size of n = 15,005. As for the post-test, the mean of the right elbow flexion movement is -56° ± 88 for a sample size of n = 5,800.

As can be seen in Table 6.9, the descriptive statistical analysis indicates that the right elbow flexion is reduced by 11°. The Independent T Test indicates that the difference of the mean right elbow flexion between the pre- and post-test is significant (p<0.01).

Table 6.9. Pre- and post-test analysis of the directional angles of right elbow flexion during functional work involving hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	15,005	-67°	35	p<0.01
Post-test	5,800	-56°	88	

*Since different participants performed the specific hairdressing techniques **for** four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Since an elbow joint ROM approaching 90° could reduce the discomfort level, this result might indicate that the ergonomics training programme could increase the risk of experiencing WMSDs for right elbow flexion during the functional hair-blow-waving task.

Furthermore, as can be seen in Figure 6.15, the task cycle graph represents the sudden shifts of the joint movement and the entire hair-blow-waving technique at the right elbow flexion. The blue line represents the right elbow flexion in the pre-test, and the green line represents the post-test values. It can be seen that the right elbow flexion between cycles numbered 66 to 84 and 65 to 84 are sudden shifts.

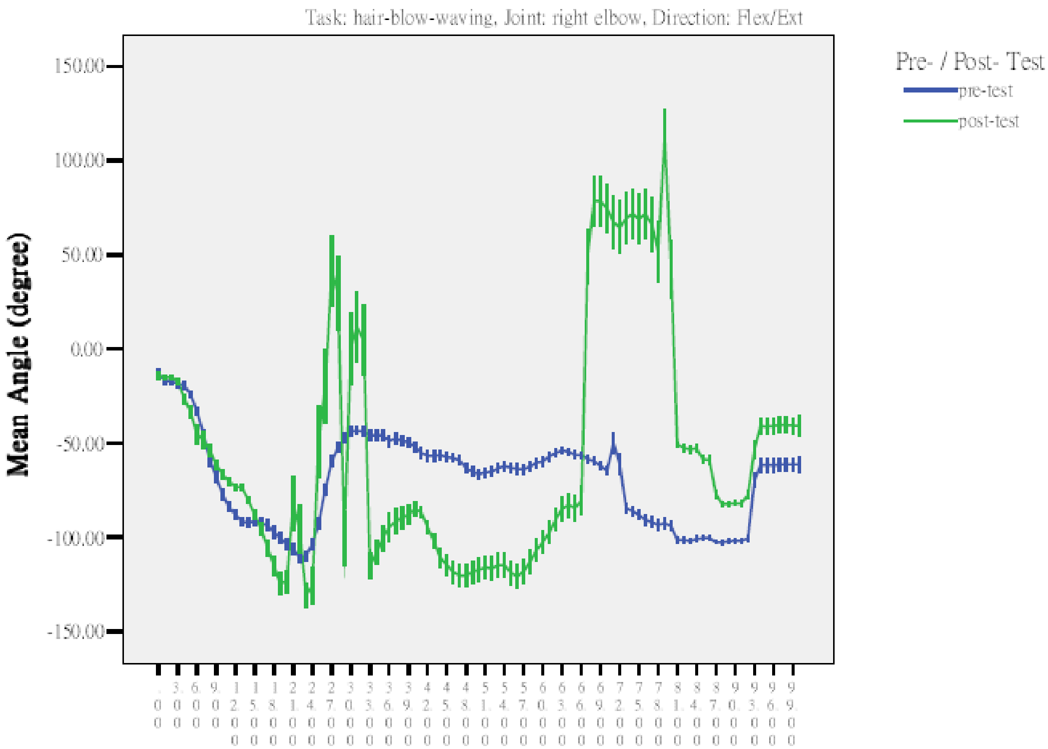

Figure 6.15. Graph of right elbow flexion during the functional hair-blow-waving technique normalized for task cycle duration and including a ± 1 standard deviation band.

Based on He and Tian's (1998) theory that the human operator's judgment is required in such cases and remains the ultimate solution for removing outliers, the raw data of the 3D kinematics values with sudden shifts will be excluded from the study and will be further discussed in section 6.5.3.

(5) Right elbow supination

As can be seen in Table 6.10, the mean of the right elbow supination movement is -42° ± 70 in the pre-test for a sample size of n = 13,944. As for the post-test, the mean of the right elbow supination movement is -63° ± 31 for a sample size of n = 5,793.

As can be seen in Table 6.10, the descriptive statistical analysis indicates that the right elbow supination is increased by 21°. The Independent T Test indicates that the difference of the mean right elbow supination between the pre- and post-tests is significant ($p<0.01$). Thus, the ergonomics training programme might increase the discomfort level in the right elbow during the functional activity of hair-blow-waving. Even so, by the adoption of the new handling technique, the shoulder flexion (-17 ^{o}) and shoulder external rotation (-9 ^{o}) were improved after the training programme.

Table 6.10. Pre- and post-test analysis of the directional angles of right elbow supination during functional work involving the hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	13,944	-42°	70	p<0.01
Post-test	5,793	-63°	31	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Furthermore, as can be seen in Figure 6.16, the task cycle graph represents the entire hair-blow-waving technique at the right elbow supination. The blue line represents the right elbow supination in the pre-test, and the green line represents the post-test values. Even though the mean joint angle is increased after the training, by the adoption of the new handling technique, the shoulder flexion (-17°) and shoulder external rotation (-9°) were improved after the training programme.

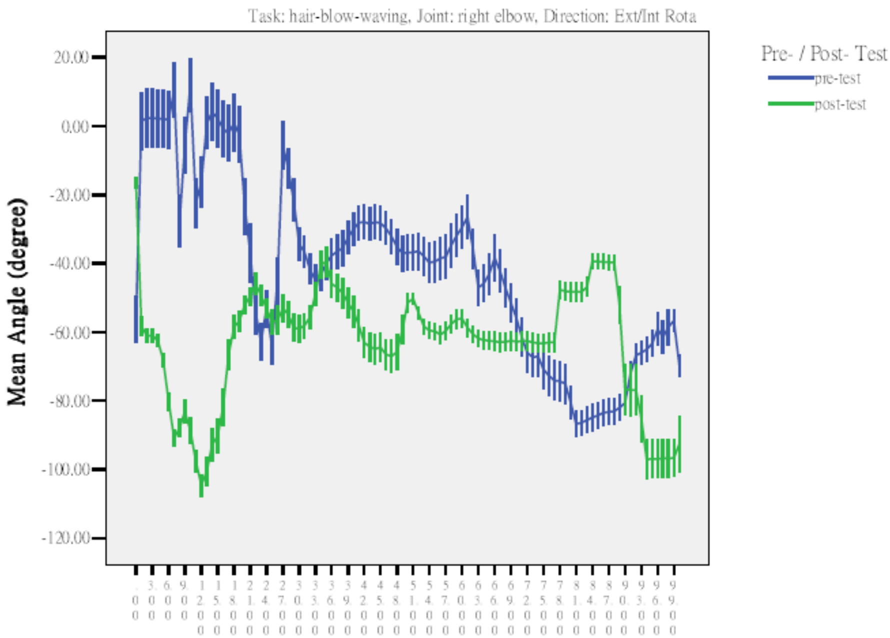

Figure 6.16. Graph of right elbow supination during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(6) Right wrist flexion

As can be seen in Table 6.11, the mean of the right wrist flexion movement is -1° ± 44 in the pre-test for a sample size of n = 20,201. As for the post-test, the mean of the right wrist flexion movement is 4° ± 23 for a sample size of n = 12,300.

As can be seen in Table 6.11, the descriptive statistical analysis indicates that the right wrist flexion is slightly increased by 3°. The Independent T Test indicates that the difference of the mean right wrist flexion between the pre- and post-tests is significant ($p<0.01$). Although the right wrist flexion is increased after the implementation of the ergonomics training programme, the overall wrist flexion movement is approaching the neutral posture (i.e. zero degrees).

Table 6.11. Pre- and post-test analysis of the directional angles of the right wrist flexion during the functional work of the hair-blow-waving activity.

Pre- and post-tests	N	Mean	Std. Deviation	Sig.
Pre-test	20,201	-1°	44	p<0.01
Post-test	12,300	4°	23	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.17, the task cycle graph represents the entire hair-blow-waving technique at the right wrist flexion. The blue line represents the right wrist flexion in the pre-test and the green line represents the post-test values. It can be seen that the right wrist flexion movement in the pre-test was around -10° to -20° between cycles numbered 18 to 75, which remained unchanged after the training. Thus, it could be said that the ergonomics training programme would not affect the right wrist flexion behaviour during the hair-blow-waving technique.

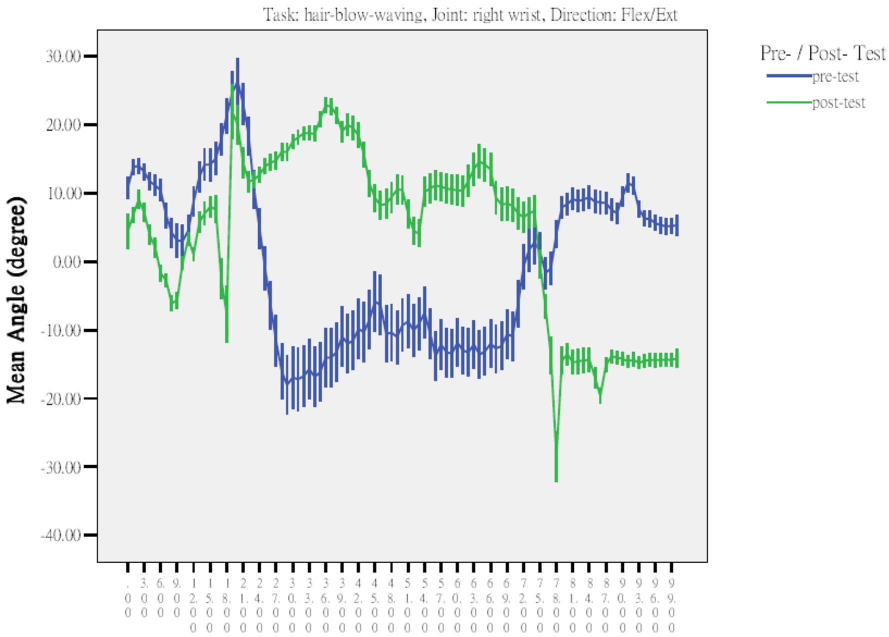

Figure 6.17. Graph of right wrist flexion during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(7) Right wrist abduction

As can be seen in Table 6.12, the mean of the right wrist abduction movement for the pre-test is -16° ± 17 for a sample size of n = 16,000. As for the post-test, the mean of the right shoulder abduction movement is -14° ± 12 for a sample size of n = 9,000.

As can be seen in Table 6.12, the descriptive statistical analysis indicates that the right wrist abduction is reduced by 2°. After that, the Independent T Test was applied to the raw data to examine the significance of the difference. This indicates that the difference of the mean right wrist abduction between the pre- and post-tests is significant ($p<0.01$). Therefore, the ergonomics training programme is effective since it can adjust the right wrist abduction to approach the neutral posture during the functional hair-blow-waving technique, which in turn reduces the risk of experiencing WMSDs.

Table 6.12. Pre- and post-test analysis of the directional angles of right wrist abduction during the functional work of hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	16,000	-16°	17	p<0.01
Post-test	9,000	-14°	12	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Figure 6.18 shows the task cycle graph representing the entire hair-blow-waving technique at the right wrist abduction. The blue line represents the right wrist abduction in the pre-test, and the green line represents the post-test values. It indicates that the right wrist abduction movement requires a similar repetitive movement between the pre- and post-tests.

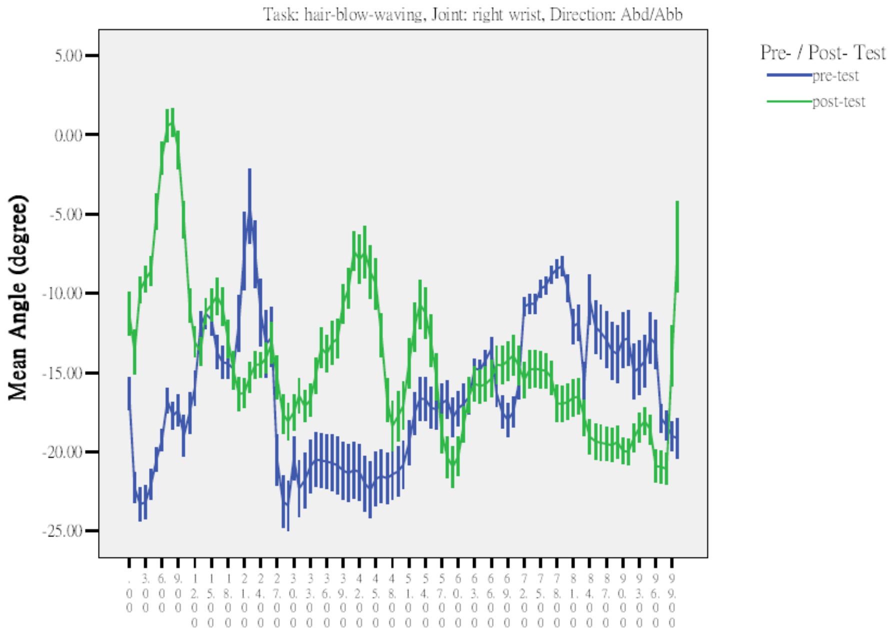

Figure 6.18. Graph of right shoulder abduction during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(8) Hip flexion

As can be seen in Table 6.13, the mean of the hip flexion movement is $-4^0 \pm 6$ in the pre-test for a sample size of n = 16,999. As for the post-test, the mean of the hip flexion movement is -5° ± 2 for a sample size of n = 3,805.

As can be seen in Table 6.13, the descriptive statistical analysis indicates that the hip flexion is increased by 1°. The Independent T Test indicates that the difference of the mean hip flexion between the pre- and post-test is significant ($p<0.01$). Although the hip flexion is increased after the implementation of the ergonomics training programme, the angle of movement is approaching the neutral posture (i.e. zero degrees).

Table 6.13. Pre- and post-test analysis of the directional angles of hip flexion during functional work associated with hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	16,999	-4°	6	p<0.01
Post-test	3,805	-5°	2	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.19, the task cycle graph represents the entire hair-blow-waving technique at the hip flexion. The blue line represents the hip flexion in the pre-test and the green line represents the post-test values. It is obvious that the curve is stabilized after the training. For instance, the hip flexion movement in the pre-test was around -5° to -12.5° between the cycles numbered 72 to 96, which was reduced to -5° to 7.5° after the training.

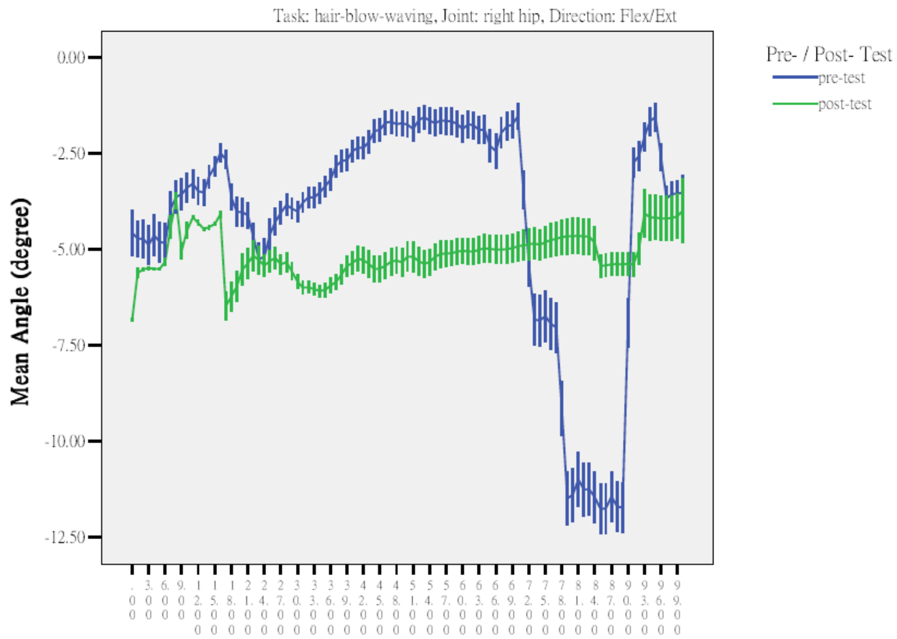

Figure 6.19. Graph of hip flexion during the functional hair-blow-waving technique normalized for task cycle duration and including a ±1 standard deviation band.

(9) Hip abduction

As can be seen in Table 6.14, for the pre-test, the mean of the hip abduction movement is 1° ± 4 for a sample size of n = 18,300. As for the post-test, the mean of the hip abduction movement is 2° ± 3 for a sample size of n = 12,200.

As can be seen in Table 6.14, the descriptive statistical analysis indicates that the hip abduction is increased by 1°. The Independent T Test indicates that the difference of the mean hip abduction between the pre- and post-tests is significant ($p<0.01$). Although the hip abduction is increased after the implementation of the ergonomics training programme, the angle of movement is approaching the neutral posture (i.e. zero degrees).

Table 6.14. Pre- and post-test analysis of the directional angles of hip abduction during the functional work of hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	18,300	1°	4	p<0.01
Post-test	12,200	2°	3	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.20, the task cycle graph represents the entire hair-blow-waving technique at the right hip abduction. The blue line represents the hip abduction in the pre-test, and the green line represents the post-test values. It is clear that the hip abduction movement in the pre-test was around 0° to -2°, which was changed to 0° to 3° after the training. Since the curve is almost the same between the pre- and post-tests, it could be said that the ergonomics training programme might not affect the hip abduction behaviour during the hair-blow-waving task.

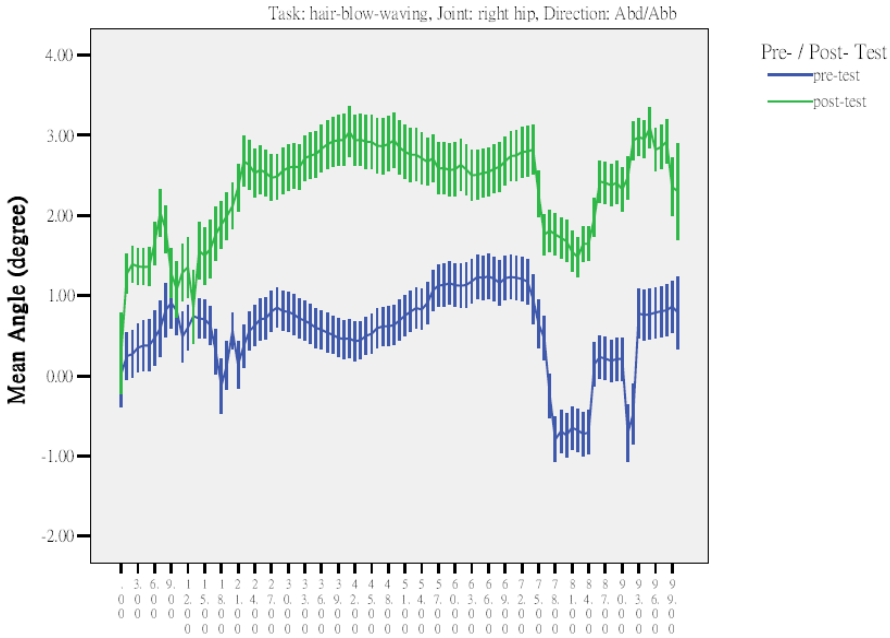

Figure 6.20. Graph of hip abduction during the functional hair-blow-waving task normalized for task cycle duration and including a ±1 standard deviation band.

(10) Hip external rotation

As can be seen in Table 6.15, the mean of the hip external rotation movement is 1° ± 5 in the pre test for a sample size of n = 14,379. As for the post test, the mean of the hip external rotation movement is 2° ± 6 for a sample size of n = 6,993.

As can be seen in Table 6.15, the descriptive statistical analysis indicates that the hip external rotation is increased by 1°. The Independent T Test indicates that the difference between the mean hip external rotations for the pre- and post-tests is significant ($p<0.01$). Although the hip external rotation is increased after the implementation of the ergonomics training programme, the angle of movement is approaching the neutral posture (i.e. zero degrees).

Table 6.15. Pre- and post-test analysis of the directional angles of hip external rotation during the functional work of hair-blow-waving activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	14,379	1°	5	$p<0.01$
Post-test	6,993	2°	6	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.21, the task cycle graph represents the entire hair-blow-waving technique at the right hip external rotation. The blue line represents the hip external rotation in the pre-test, and the green line represents the post-test values. It is clear that the hip external rotation movement in the pre-test was around 0° to -5°, which was changed to 0° to -10° after the training. Since the curve is almost the same between the pre- and post-tests, it could be said that the ergonomics training programme might not affect the hip external rotation behaviour during the hair-blow-waving task.

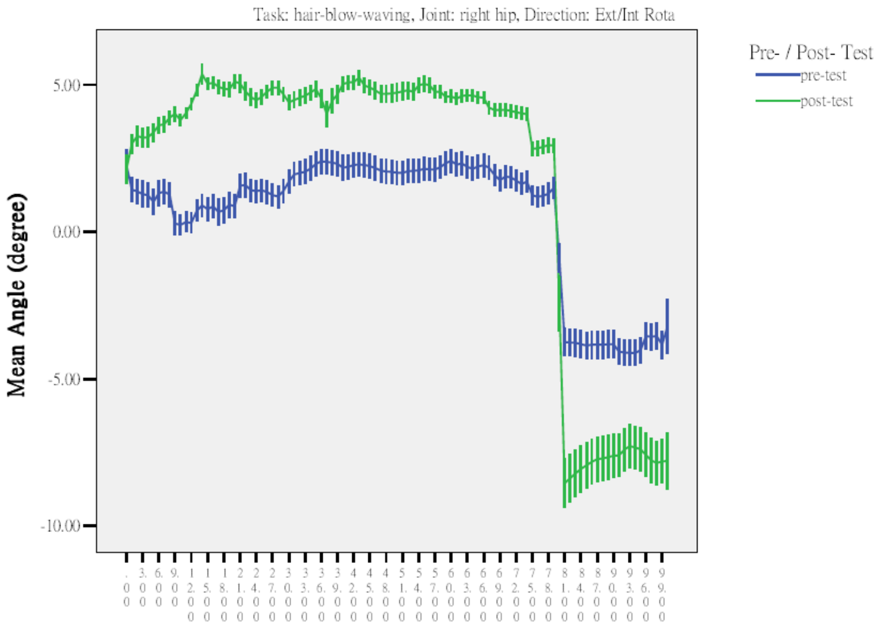

Figure 6.21. Graph of hip external rotation during the functional hair-blow-waving technique normalized to task cycle duration and including a ±1 standard deviation band.

6.4.5. Validity study (Hair- straightening)

As can be seen in Table 6.16, the Independent T Test is used to examine the significance of the difference between the pre- and post-tests.

Table 6.16. The summary of the result of Independent T Test of the joint activity during hair-straightening.

Joint ROMs	Direct	Degree (^{o})			Significance
		Pilot Test	Evaluation Test	Improvement*	
Shoulder	Flex/Ext	-18	-17	0	p<0.01
Shoulder	Abd/Abb	27	41	+14	p<0.01
Shoulder	Ext/Int Rota	-52	-27	-26	p<0.01
Elbow	Flex/Ext	-18	-30	+11**	p<0.01
Elbow	Pronation/Supination(palm up)	-46	-38	-9	p<0.01
Wrist	Flex/Ext	6	1	-5	p<0.01
Wrist	Abd/Abb	0	2	+2	p<0.01
Hip	Flex/Ext	-5.8	-5.3	0	p<0.01
Hip	Abd/Abb	0.5	0.9	0	p<0.01
Hip	Ext/Int Rota	-1.5	-2.3	+1	p<0.01

* A negative value means that the ergonomics training programme has the benefit of improving a risky joint ROM. Conversely, a positive value means that the ergonomics training programme has had the effect of improving a risky joint ROM.

** The elbow flexion approaches to 90°, which could reduce the discomfort level. This differs from the other joint ROMs where an increased joint angle mean increasing the discomfort. In this case, the elbow flexion is decreased by 11°, which means increasing the discomfort level. This is caused by a very large standard deviation that will be further explained in the following sections.

The detailed analysis and associated description of the specific body movement is summarized in the following sections. The composite graphs, known as task cycle graphic analysis, will be used to demonstrate the movement of a joint during each task. In the task cycle graphic analysis, the joint movement involved in the functional work of the task was normalized for task cycle duration and included a ±1 standard deviation band.

(1) Right shoulder flexion

As can be seen in Table 6.17, for the pre-test, the mean of the right shoulder flexion movement is -18° ± 37 for a sample size of n = 10,381. As for the post-test, the mean of the right shoulder flexion movement is -17° ± 38 for a sample size of n = 13,900.

As can be seen in Table 6.17, the descriptive statistical analysis indicates that the right shoulder flexion is reduced by 1°. The Independent T Test indicates that the difference of the mean right shoulder flexion between the pre- and post-tests is not significant (p=0.339). Therefore, it is clear that there is no change in the mean right shoulder flexion after the implementation of the ergonomics training programme.

Table 6.17. Pre- and post-test analysis of the directional angles of hip flexion during functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	10,381	-18°	37	p=0.339
Post-test	13,900	-17°	38	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.22, the task cycle graph represents the entire hair-straightening technique at the right shoulder flexion. The blue line represents the right shoulder flexion in the pre-test, and the green line represents the post-test values. It is obvious that the curve is stabilized after the training. For instance, the right shoulder flexion movement in the pre-test was around 0° to ±40° for the cycles numbered 63 to 90, which was reduced to -20° from -40° after the training. It could be said that the ergonomics training programme might not affect the right shoulder flexion movement during the hair-straightening technique, but the task cycle graphic further validates that the conventional manual handling technique for hair-straightening requires a larger interval which has been shortened by introducing the ergonomics knowledge of the new manual handling technique.

Figure 6.22. Graph of right shoulder flexion during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(2) Right shoulder abduction

As can be seen in Table 6.18, for the pre-test, the mean of the right shoulder abduction movement is 27° ± 34 in the pre-test for a sample size of n = 12,300. As for the post-test, the mean of the right shoulder abduction movement is 41° ± 47 for a sample size of n = 8,400.

As can be seen in Table 6.18, the descriptive statistical analysis indicates that the right shoulder abduction is increased by 14°. The Independent T Test indicates that the difference of the mean right shoulder abduction between the pre- and post-tests is significant ($p<0.01$).

Table 6.18. Pre- and post-test analysis of the directional angles of the right shoulder abduction during functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	12,300	27°	34	p<0.01
Post-test	8,400	41°	47	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Furthermore, as can be seen in Figure 6.23, the task cycle graph represents the entire hair-straightening technique at the right shoulder abduction movement. The blue line represents the right elbow supination in the pre-test, and the green line represents the post-test values. Even though the mean joint angle is increased after the training, by introducing the ergonomics knowledge of the new handling technique for hair-straightening, the shoulder external rotation (-26°), elbow flexion (+11°) and elbow pronation (-9°) were improved after the training programme.

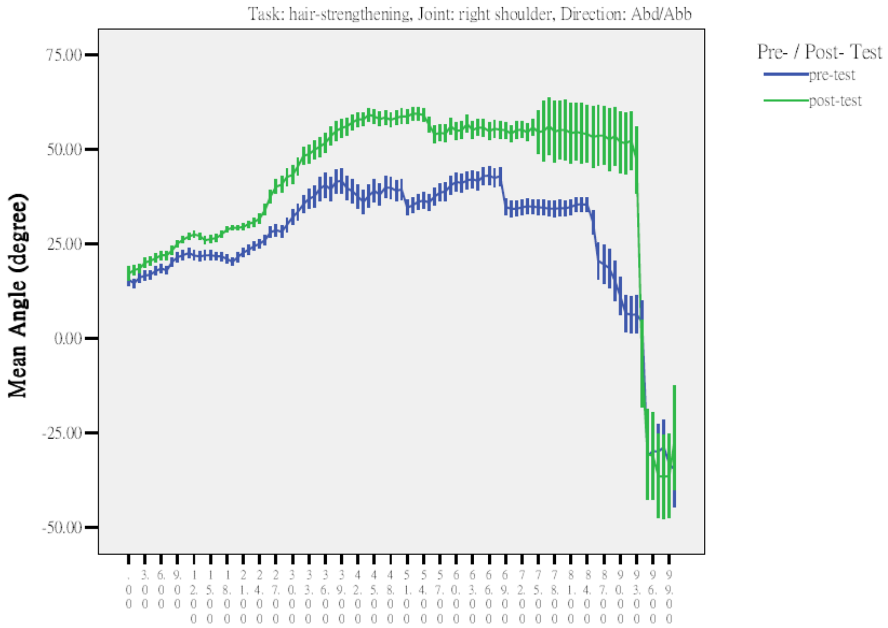

Figure 6.23. Graph of right shoulder abduction during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(3) Right shoulder external rotation

As can be seen in Table 6.19, the mean of the right shoulder external rotation movement is -52° ± 77 in the pre-test for a sample size of n = 6,800. As for the post-test, the mean of the right shoulder external rotation movement is -27° ± 63 for a sample size of n = 10,580.

As can be seen in Table 6.19, the descriptive statistical analysis indicates that the right shoulder external rotation is reduced by 26°. The Independent T Test was then applied to the raw data to examine the significance of the difference. This indicates that the difference of the mean right shoulder external rotation between the pre- and post-tests is significant ($p<0.01$). Therefore, the ergonomics training programme is effective since it can adjust the right shoulder external rotation to approach the neutral posture during the functional hair-straightening technique, which in turn reduces the risk of experiencing work-related musculoskeletal disorders.

Table 6.19. Pre- and post-test analysis of the directional angles of right shoulder external rotation during the functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre- test	6,800	-52°	77	p<0.01
Post-test	10,580	-27°	63	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Figure 6.24 is the task cycle graph representing the entire hair-straightening technique at the right shoulder external rotation. The blue line represents the right shoulder external rotation in the pre test, and the green line represents the post test values. It is obvious that the overall right shoulder external rotation is reduced after the ergonomics training.

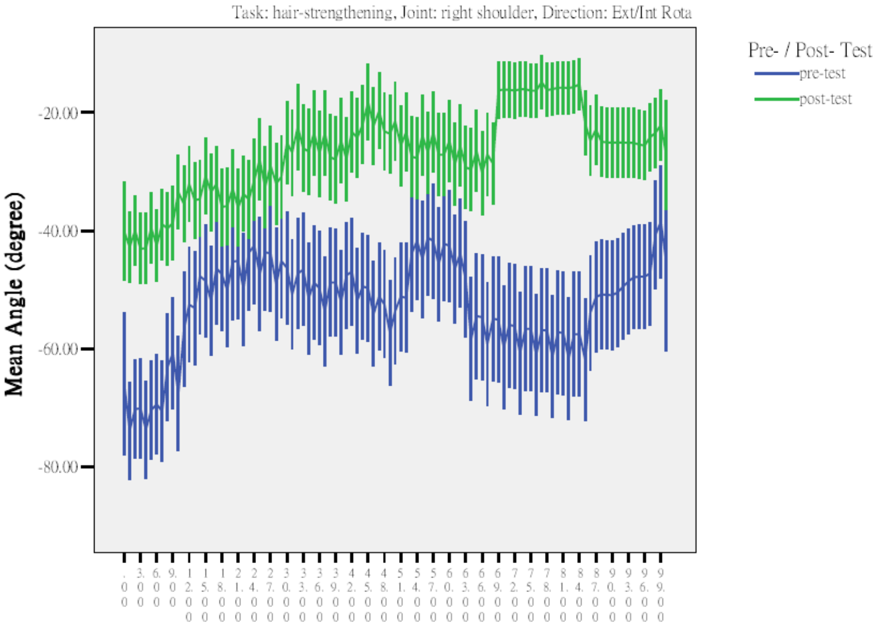

Figure 6.24. Graph of right shoulder external rotation during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(4) Right elbow flexion

As can be seen in Table 6.20, the mean of the right elbow flexion movement is -18° ± 85 in the pre test for a sample size of n = 8,203. As for the post test, the mean of the right elbow flexion movement is -30° ± 81 for a sample size of n = 11,824.

As can be seen in Table 6.20, the descriptive statistical analysis indicates that the right elbow flexion is increased by 11°. The Independent T Test was then applied to the raw data to examine the significance of the difference. The result indicates that the difference between the mean right elbow flexions for the pre- and post-tests is significant ($p<0.01$). As mentioned earlier, the elbow joint ROM which approaches 90° could reduce the discomfort level.

Table 6.20. Pre- and post-test analysis of the directional angles of right elbow flexion during functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre- test	8,203	-18°	85	p<0.01
Post-test	11,824	-30°	81	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Since an elbow joint ROM approaching 90° could reduce the discomfort level, this result might indicate that the ergonomics training programme could reduce the discomfort level and the risk of experiencing WMSDs for right elbow flexion during the functional hair-straightening technique.

Figure 6.25 is the task cycle graph representing the entire hair-straightening technique at the right elbow flexion. The blue line represents the right elbow flexion in the pre test and the green line represents the post test values. It is obvious that the overall right elbow flexion after the ergonomics training is increased from 25° to 50° at both the beginning and the end of the functional activity (i.e. the elbow flexion approaching 90 degree can decrease the discomfort level in the front arm) .

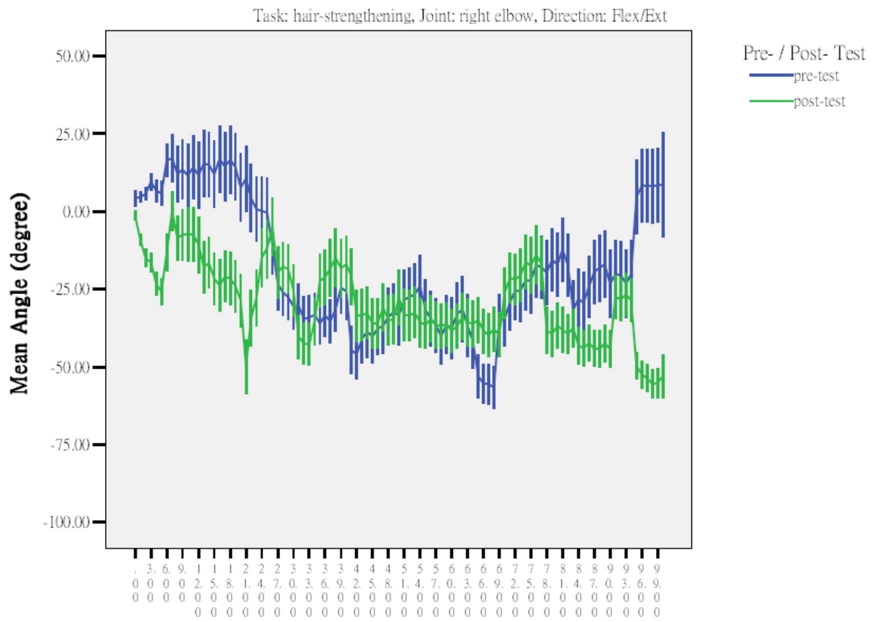

Figure 6.25. Graph of right elbow flexion during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(5) Right elbow supination

As can be seen in Table 6.21, the mean of the right elbow supination movement is -46° ± 68 in the pre test for a sample size of n = 11,579. As for the post test, the mean of the right elbow supination movement is -38° ± 61 for a sample size of n = 6,491.

As can be seen in Table 6.21, the descriptive statistical analysis indicates that the right elbow supination is reduced by 8°. The Independent T Test indicates that the difference of the mean right elbow supination between the pre and post tests is significant ($p<0.01$). Since the elbow has a neutral posture with the elbow supination palm-up, the discomfort level could be reduced. Thus, the ergonomics training programme is effective.

Table 6.21. Pre- and post-test analysis of the directional angles of right elbow supination during the functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	11,579	-46°	68	p<0.01
Post-test	6,491	-38°	61	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Figure 6.26 is the task cycle graph representing the entire hair-straightening technique at the right shoulder supination**.** The blue line represents the right elbow supination in the pre test, and the green line represents the post test values. It is obvious that the overall right elbow supination after the ergonomics training is reduced at the beginning and at the end of the functional activity.

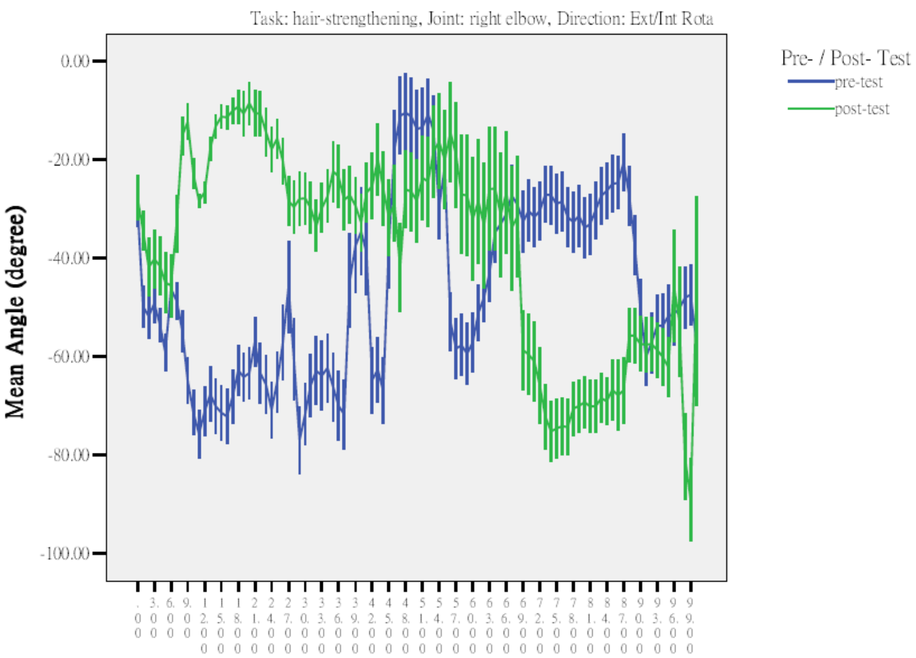

Figure 6.26. Graph of right elbow supination during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(6) Right wrist flexion

As can be seen in Table 6.22, the mean of the right wrist flexion movement is 0° ± 25 in the pre test for a sample size of n = 6,317. As for the post test, the mean of the right wrist flexion movement is 2° ± 36 for a sample size of n = 3,400.

As can be seen in Table 6.22, the descriptive statistical analysis indicates that the right wrist flexion is slightly increased by 2°. The Independent T Test indicates that the difference of the mean right wrist flexion between the pre- and post-tests is significant ($p<0.01$). Although the right wrist flexion is increased after the implementation of the ergonomics training programme, the overall wrist flexion movement is approaching the neutral posture (i.e. zero degrees).

Table 6.22. Pre- and post-test analysis of the directional angles of right wrist flexion during functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	6,317	0°	25	p<0.01
Post-test	3,400	2°	36	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.27, the task cycle graph represents the entire hair-straightening technique at the right wrist flexion. The blue line represents the right wrist flexion in the pre test, and the green line represents the post test values. It can be seen that the overall right wrist flexion after the ergonomics training is not greatly changed from the original.

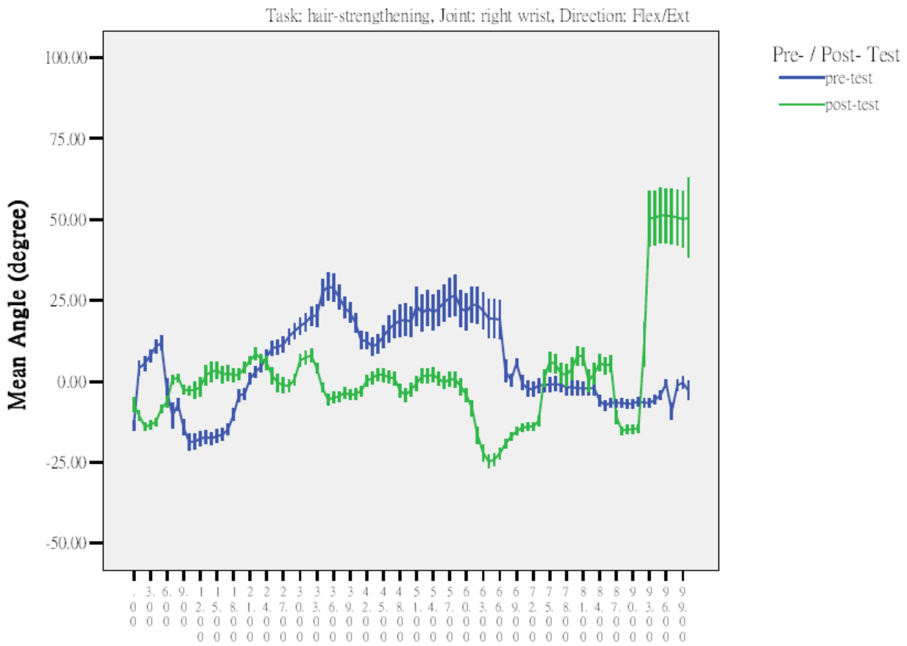

Figure 6.27. Graph of right wrist flexion during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(7) Right wrist abduction

As can be seen in Table 6.23, the mean of the right wrist abduction movement is 6° ± 31 in the pre test for a sample size of n = 8,732. As for the post test, the mean of the right shoulder abduction movement is 1° ± 28 for a sample size of n = 6,600.

As can be seen in Table 6.23, the descriptive statistical analysis indicates that the right wrist abduction is reduced by 5°. The Independent T Test was then applied to the raw data to examine the significance of the difference. This indicates that the difference of the mean right wrist abduction between the pre- and post-tests is significant ($p<0.01$). Therefore, the ergonomics training programme is effective since it can adjust the right wrist abduction to approach the neutral posture during the functional hair-straightening technique, which in turn reduces the risk of experiencing WMSDs.

Table 6.23. Pre- and post-test analysis of the directional angles of right wrist abduction during the functional work associated with hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	8,732	6°	31	$p<0.01$
Post-test	6,600	1°	28	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

Figure 6.28 shows the task cycle graph representing the entire hair-straightening technique at the right wrist abduction. The blue line represents the right wrist abduction in the pre-test, and the green line represents the post-test values. It can be seen that the overall right wrist abduction after the ergonomics training is greatly improved from the original.

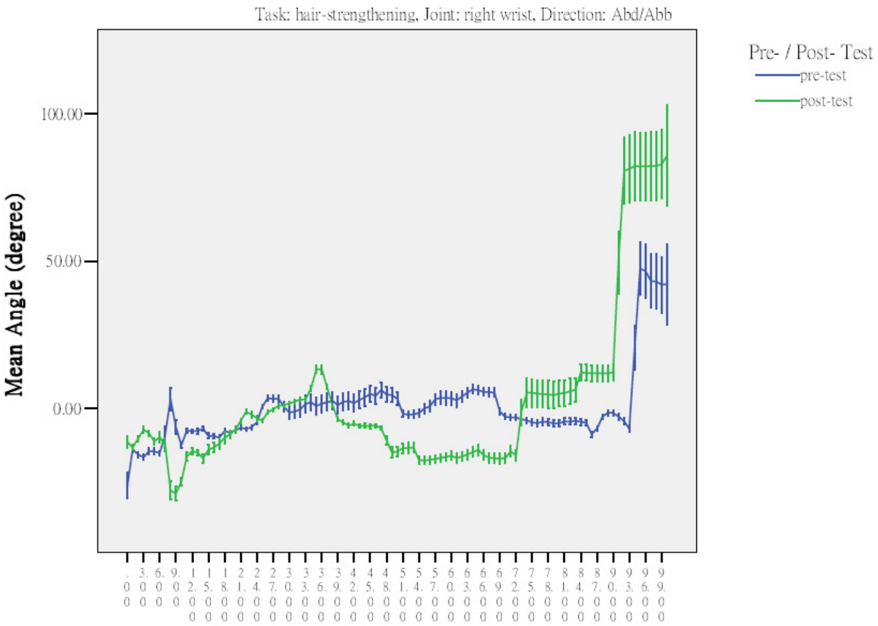

Figure 6.28. Graph of right wrist abduction during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(8) Hip flexion

As can be seen in Table 6.24, the mean of the hip flexion movement is -5.8° ± 4 in the pre test for a sample size of n = 22,381 As for the post test, the mean of the hip flexion movement is -5.3° ± 5 for a sample size of n = 13,900.

As can be seen in Table 6.24, the descriptive statistical analysis indicates that the hip flexion is increased by 0.5°. The Independent T Test indicates that the difference of the mean hip flexion between the pre and post tests is significant ($p<0.01$). Although the hip flexion is increased after the implementation of the ergonomics training programme, the angle movement is approaching the neutral posture (i.e. zero degrees).

Table 6.24. Pre- and post-test analysis of the directional angles of hip flexion during functional work involving a hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	22,381	-5.8°	4	p<0.01
Post-test	13,900	-5.3°	5	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.29, the task cycle graph represents the entire hair-straightening technique at the hip flexion. The blue line represents the hip flexion in the pre test, and the green line represents the post test values. It can be seen that the overall hip flexion after the ergonomics training is not greatly changed from the original.

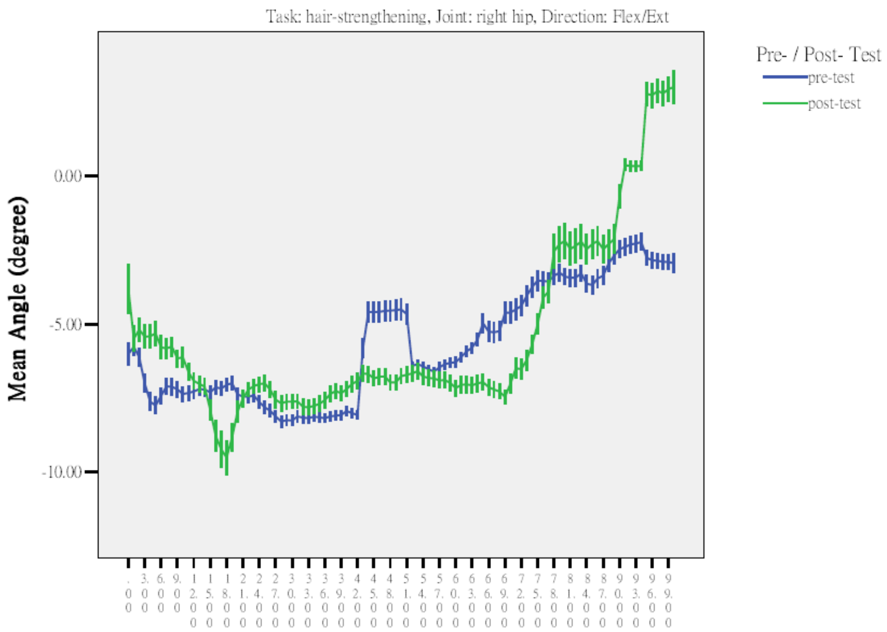

Figure 6.29. Graph of hip flexion during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(9) Hip abduction

As can be seen in Table 6.25, the mean of the hip abduction movement is 0.5° ± 3 in the pre test for a sample size of n = 12,300. As for the post test, the mean of the hip abduction movement is 0.9° ± 3 for a sample size of n = 8,400.

As can be seen in Table 6.25, the descriptive statistical analysis indicates that the hip abduction is increased by 0.4°. The Independent T Test indicates that the difference of the mean hip abduction between the pre- and post-tests is significant ($p<0.01$). Although the hip abduction is increased after the implementation of the ergonomics training programme, the angle of movement is approaching the neutral posture (i.e. zero degrees).

Table 6.25. Pre- and post-test analysis of the directional angles of hip abduction during functional work involving a hair-straightening activity.

Pre- and post-tests	N	Mean	Std. Deviation	Sig.
Pre-test	12,300	0.5°	3	p<0.01
Post-test	8,400	0.9°	3	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.30, the task cycle graph represents the entire hair-straightening technique at the right hip abduction. The blue line represents the hip abduction in the pre test and the green line represents the post test values. It can be seen that the overall hip abduction after the ergonomics training is not greatly changed from the original.

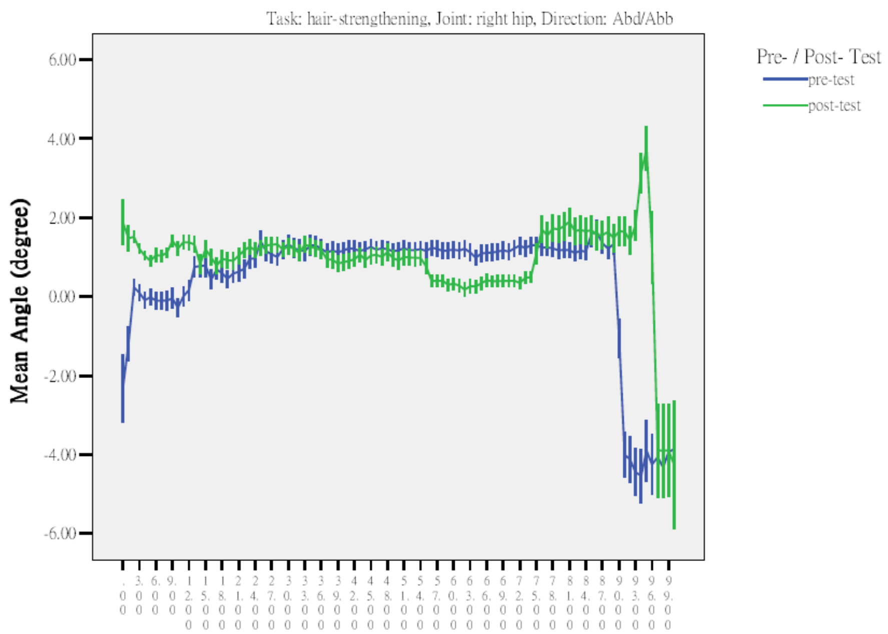

Figure 6.30. Graph of hip abduction during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

(10) Hip external rotation

As can be seen in Table 6.26, the mean of the hip external rotation movement in the pre-test is -1.5° ± 10 for a sample size of n = 6,796. As for the post-test, the mean of the hip external rotation movement is -2.3° ± 7 for a sample size of n = 10,463.

As can be seen in Table 6.26, the descriptive statistical analysis indicates that the hip external rotation is increased by 0.5°**.** The Independent T Test indicates that the difference in the mean hip external rotation between the pre- and post-tests is significant ($p<0.01$). Although the hip external rotation is increased after the implementation of the ergonomics training programme, the angle of movement is approaching the neutral posture (i.e. zero degrees).

Table 6.26. Pre- and post-test analysis of the directional angles of hip external rotation during functional work of hair-straightening activity.

Pre- and post-tests	N*	Mean	Std. Deviation	Sig.
Pre-test	6,796	-1.5°	10	p<0.01
Post-test	10,463	-2.3°	7	

*Since different participants performed the specific hairdressing techniques for four blocks, the time spent on each data set might be varied differently owing to the individual skill/technique difference.

As can be seen in Figure 6.31, the task cycle graph represents the entire hair-straightening technique at the right hip external rotation. The blue line represents the hip external rotation in the pre test, and the green line represents the post test values. It can be seen that the overall hip flexion after the ergonomics training is not greatly changed from the original.

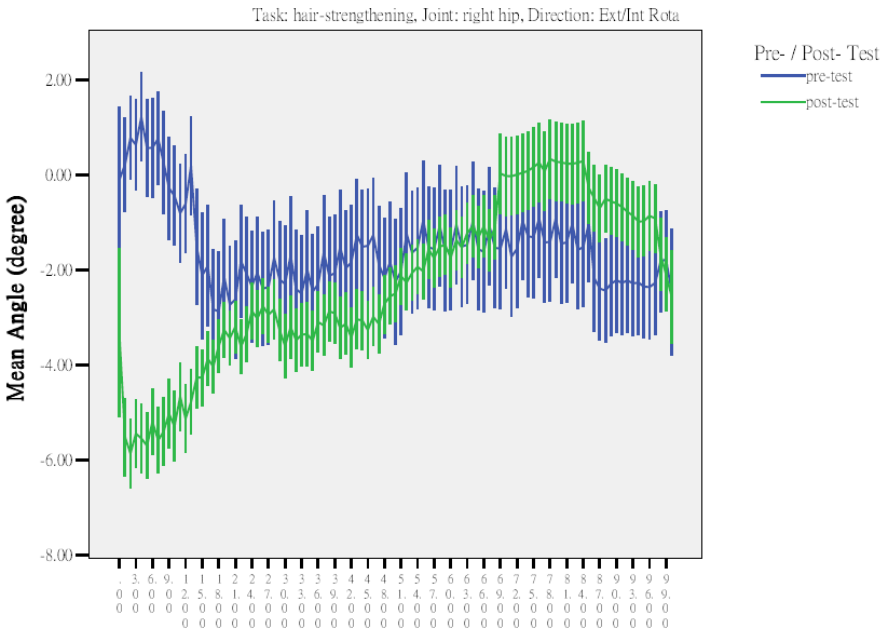

Figure 6.31. Graph of hip external rotation during the functional hair-straightening technique normalized for task cycle duration and including a ±1 standard deviation band.

6.5. Discussion

This study achieved its aims which were to implement 3D motion analysis and associated cycle task analysis to validate of the effectiveness of the ergonomics training for the study of the right upper extremity kinematics during the functional activities of hair-blow-waving and hair-straightening techniques, based on a comparison of awkward posture movements between the pilot and evaluation tests. The analysis provides a better understanding as to how these techniques are performed to reduce the ROMs on the right upper limb.

This study has established the kinematic data from healthy and normal hairdressers; optimal trajectory paths can be determined taking into account the limits of individual transradial prostheses and residual limbs. The techniques selected for this study were designed to simulate common hair-blow-waving and hair-straightening requirements with the extremes of motion of the upper limb being identified by direct observation using a digital video recorder prior to the study.

It is known that 3D techniques have not previously been used to measure the upper limb motion during hairdressing techniques. Based on this research, several unique characteristic curve patterns were seen in certain movement graphs using the cycle task analysis. Moreover, some of the composite graphs representing joint motions showed a small standard deviation at the beginning and end of the task cycle duration. These appropriate paths with a small ± standard deviation band indicate that these hairdressers have been properly trained to develop and adopt appropriate techniques for completing common hair-blow-waving and hair-straightening techniques. Thus, this study suggests that the upper limb is adaptive, showing the ability to perform the same tasks using different kinematic strategies, which, in turn, validates the feasibility of the 3D motion analysis based on the proposed trial protocol.

6.5.1. The success of the ergonomics training aimed at risk prevention with complex hairdressing techniques

The analysis indicates the success of the programme for both hair-blow-waving and hair-straightening techniques. For instance, 90% of the directional joint ROMs were improved significantly for the hair-straightening technique, followed by 80% for the hair-blow-waving technique: In this study, the training intervention programme was used to highlight the usefulness of the 3D motion analysis and associated task cycle graph for the study of the training effectiveness. It aimed to educate hairdressers about how to maintain minimized - to approach zero - joint angles for the upper limbs to help them achieve a more neutral posture during the performance of the high-risk techniques and working postures. The programme consisted of four parts within a 16-week academic semester, including the pilot test, the two-day lecture, the group study and the evaluation test.

Further findings include: firstly, it was also revealed that the elbow flexion could be the most difficult joint ROM to be studied for the hair-blow-waving technique. This is because the elbow is located around the manikin-head where the 3D motion camera could not capture its motion.

Secondly, it was discovered that the shoulder abduction movement during the hair-straightening technique is the most difficult to improve compared with other joint

ROMs. This is because the hair-straightening activity requires the whole arm to pull the hair-straightening iron. It can be expected that, if the other joint ROMs are reduced, the shoulder abduction will be increased accordingly. Thus, this study suggests that risk prevention must become part of the ergonomics training programme and be combined with a design innovation for the conventional hair-straightening iron.

Such measurement of the motion requirements of the upper extremity during hair-blow-waving and hair-straightening techniques has several different potential clinical applications. Regardless of their underlying condition, hairdressers with limited upper limb function and skill performance can be studied using the protocol proposed in this study. Thus, the same protocol is recommended to be implemented for various hairdressing techniques in the future, such as hair-cutting and hair-perming.

6.5.2. The use of the task cycle graph for the study of complex hairdressing techniques

It is strongly recommended that the use of conventional statistical analysis and the task cycle graph should be combined for the study of complex hairdressing techniques because the task cycle graph can provide a qualitative explanation of the joint movement during the functional task. For instance, after the statistic analysis, the task cycle graph is then used to explain the joint movement during the functional activity.

In some cases, the task cycle graphs are particularly useful to demonstrate the joints during each task and to identify the awkward postures, even if the statistical analysis indicates that the effectiveness of the ergonomics training programme is not so obvious. An awkward working posture is defined as the posture having a joint range that departs from the neutral posture and in which the angle of the motion is over 25°, for instance, most of the hip movements were increased by less than 5°.

Moreover, the task cycle graph for the study of a complex hairdressing task can also be used to support the statistical analysis of the results. For the joint movement represented by the normalized task cycle duration in the case study of the ergonomics training effectiveness for the right wrist flexion during the functional work associated with a hair-blow-waving activity, the statistical analysis indicates that the mean right wrist flexion is $-1^{o} \pm 44$ and $4^{o} \pm 23$. Through the use of the task cycle graph, the change in the wrist flexion movement over the normalized task cycle duration can be seen clearly.

6.5.3. Human operator's judgment for removing outliers

Based on the use of the task cycle graph, it is possible in some cases to remove the outliers based on the human operator's judgment. For instance, the descriptive statistical analysis in the validity study of the right elbow flexion indicates that this flexion is reduced by 11°. This result might indicate that the ergonomics training programme could increase the risk of experiencing WMSDs for right elbow flexion during the functional hair-blow-waving technique.

However, it can be seen that the right elbow flexion between the cycles numbered 66 to 84 and 65 to 84 are sudden shifts, as shown in Figure 6.15. Since the 3D motion analysis is highly accurate, and the advanced filtering algorithm for the statistical smoothness characteristics of the camera data operates under the assumption that a human movement trajectory should not contain any sudden shifts, then, He and Tian’s (1998) theory that the human operator’s judgment is required in such cases remains the ultimate solution for removing outliers and has been applied here. Hence, the raw data of the 3D kinematics values with sudden shifts will be excluded from the study, as shown in Figure 6.32.

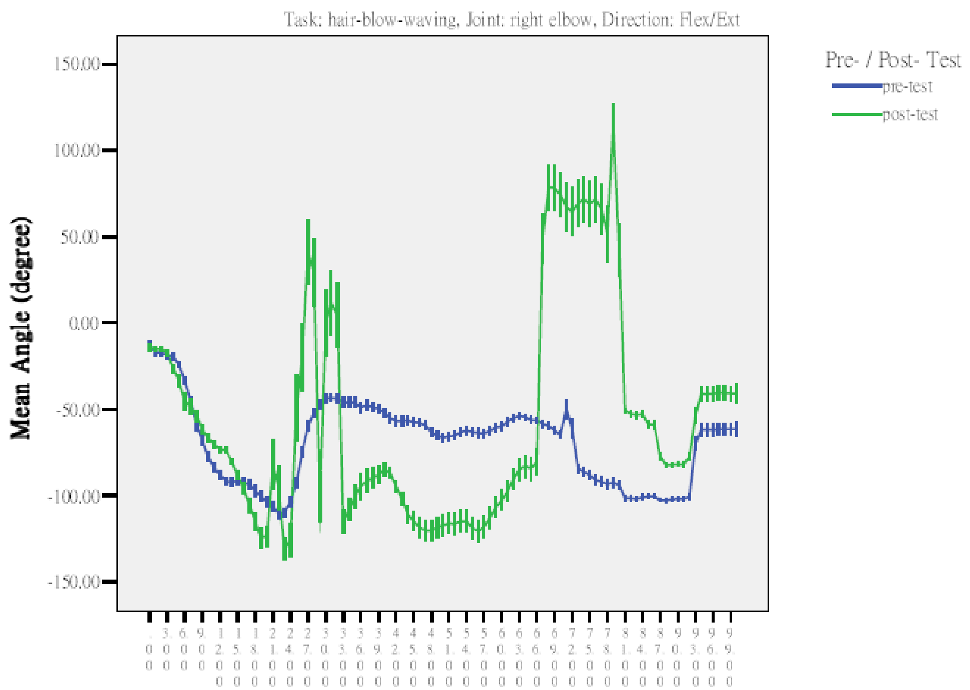

Figure 6.15. Graph of right elbow flexion during the functional hair-blow-waving technique normalized for the task cycle duration and including a ± 1 standard deviation band

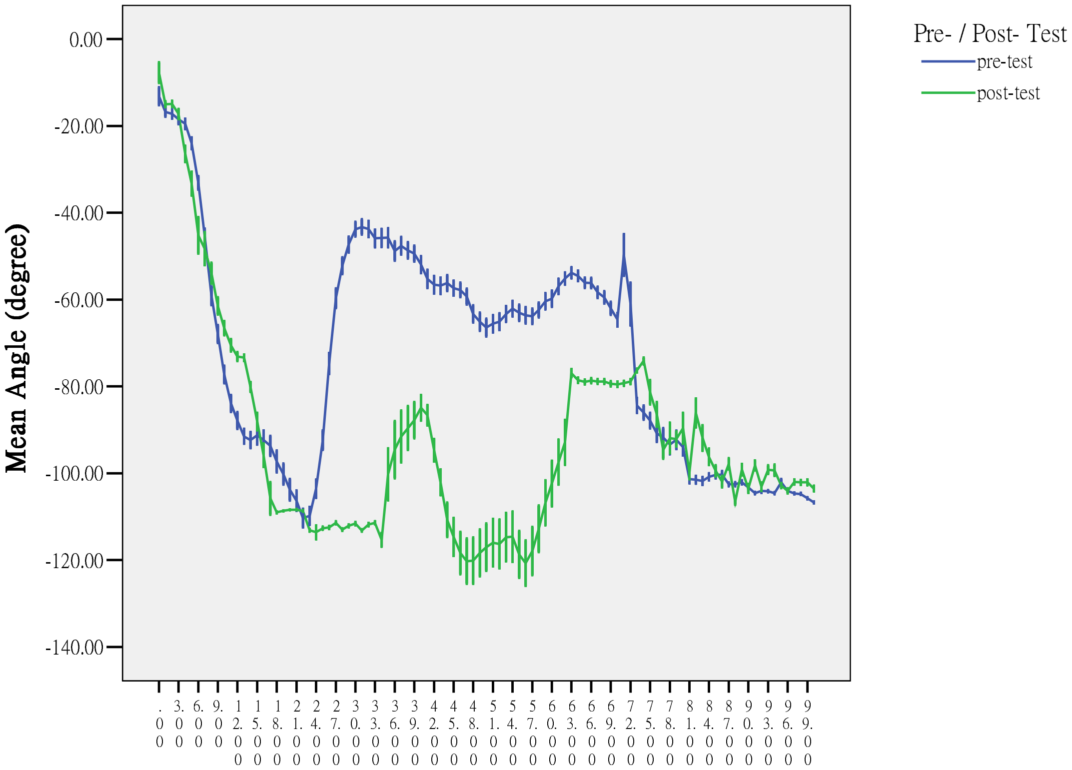

Figure 6.32. Graph of right elbow flexion during the functional hair-blow-waving technique normalized for task cycle duration (after manual adjustment of the raw data)

Having removed the raw data showing the sudden shifts, Table 6.27 further shows that the standard deviation of the raw data collected from the evaluation test decreases from the original 88° to 34° after the sudden shifts are removed, which is more stable than the previous data.

Table 6.27. Pre- and post-test analysis of the directional angles of right elbow flexion during functional work involving hair-blow-waving activity (after manual adjustment of the raw data)

Pre- and post-tests	N	Mean	Std. Deviation	Sig.
Pre- test	15,005	-69°	35	p<0.01
Post-test	5,800	-93°	**34***	

* Std. deviation falls from the original 88° to 34°, which is more stable than the previous data.

6.5.4. Indications that a long-term ergonomics training programme is required

In order to reduce the risk of the right arm movement, it is proposed to adopt the new manual handling technique instead of the conventional one for the hair-blow-waving technique, as shown in Figure 6.1 and 6.2:

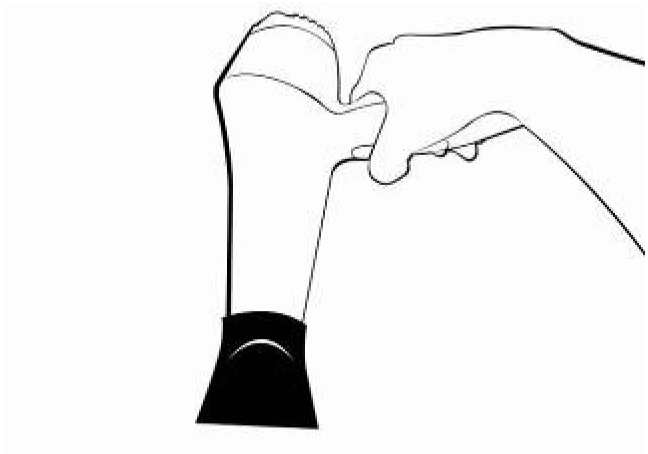

Figure 6.1. Conventional manual handling techniques increase the discomfort in the right arm in particular for the shoulder and wrist.

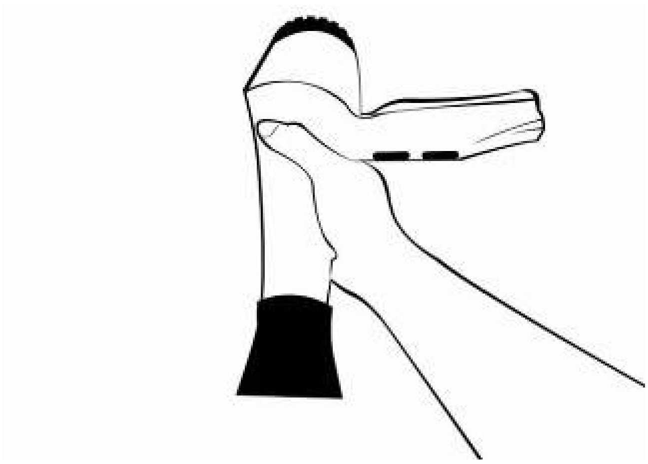

Figure 6.2. New manual handling techniques could reduce the discomfort in the right arm, in particular for the shoulder and wrist.

After the ergonomics training, the right elbow supination is increased by 21^{o}, even though the rest of the movements have been improved significantly ($p>0.05$). Thus, it is necessary to know why the elbow supination could not be improved. The reason appears to be the adoption of the new handling technique that improved the shoulder flexion by -17^{o} and shoulder external rotation by -9^{o}.

Moreover, the right shoulder abduction movement in the hair-straightening technique was also increased after the training. Even though the mean joint angle was increased after the training, by introducing the ergonomics knowledge of the new handling technique for hair-straightening, the shoulder external rotation (-26^{o}), elbow flexion ($+11^{o}$) and elbow pronation (-9^{o}) were improved after the training programme.

To sum up, the result emphasizes that the balance of the elbow and shoulder movements need to be further studied and the implementation of the ergonomics training intervention should continue in order to improve the elbow movement in the long-term.

6.5.5 Limitation of 3D motion analysis for the study of complex hairdressing techniques

As mentioned in the research limitations, the raw data of the 3D kinematics values used in this study suffer from being partially blocked by the manikin-head and left arm, which causes sudden shifts. In this study, since the advanced filtering algorithm for the statistical smoothness characteristics of the camera data was not employed, the raw data of the 3D kinematics values with sudden shifts can be seen from the task cycle graph. Thus, the human operator's judgment is still required in such cases and remains the ultimate solution for removing outliers (He and Tian, 1998). For instance, in this case study of the effectiveness of ergonomics training on the right elbow flexion during the functional work for a hair-blow-waving activity, it was revealed that the right elbow flexion between cycles number 66 and 84 and between 65 and 84 are sudden shifts, as shown in Figure 6.27. It is therefore suggested that the raw data in such cases might be normalised by the use of the advanced filtering algorithm for the statistical smoothness characteristics of the camera data.

6.6. Conclusion

Since hair-blow-waving and hair-straightening techniques are complex to observe, the effectiveness of the training programme might be difficult to measure based on direct observation or a qualitative questionnaire assessment. Furthermore, the effectiveness of the intervention training programme for hairdressers remains unknown. Thus, 3D motion analysis is proposed for the identification of the awkward working postures and for the validation of the effectiveness of the ergonomics training since there is a lack of 3D motion analysis dedicated to hairdressing techniques.

This study aims to implement 3D Motion analysis and associated cycle task analysis to validate the effectiveness of the ergonomics training for the study of the right upper extremity kinematics during the functional activities of hair-blow-waving and hair-straightening techniques, based on the comparison of pilot (pre)-test and evaluation (post)-test data for the awkward movements. It is hope that this study could facilitate the use of these 3D motion analysis techniques to analyze the processes involved in a hairdresser's technique.

As a result, the success of the ergonomics training on the risk prevention with complex hair-blow-waving and hair-straightening techniques has been validated. For instance, 90% of the directional joint ROMs were improved significantly for the hair-straightening technique and by 80% for hair-blow-waving technique. Furthermore, the study explores the usefulness of the task cycle graph for the study of complex hairdressing techniques and a human operator's judgment for removing outliers. This emphasises the need for long-term ergonomics training in the future. It also highlights the limitations of 3D motion analysis for the study of complex hairdressing techniques, an aspect of this work which also requires further study.

Chapter Seven: General Discussion

7.1. Introduction

This chapter aims to discuss the following issues:

- Inter-relationships between the primary studies;
- The development cycle of WMSDs associated with risk factors;
- Ergonomics training that improves awkward working postures within the techniques of hair-blow-waving and hair-straightening;
- The advantages and disadvantages of 3D motion analysis for the validation of the training effectiveness within the techniques of hair-blow-waving and hair-straightening.

7.2. Inter-relationships between the primary studies

This research used the following three methods: a hair-dresser-orientated musculoskeletal questionnaire survey, postural analysis of the upper limb regions using RULA, and the use of 3D motion analysis for the validation of the effectiveness of the ergonomics training. Based on the implementation of the methodology, the study significantly improves the awkward working postures found in risky hairdressing techniques as shown in the 3D motion analysis.

7.2.1. Hairdresser-orientated musculoskeletal questionnaire survey

In Chapter 4, there are two versions of the hairdresser-orientated musculoskeletal questionnaire used in this research: In the pilot study, the first version of the questionnaire was used for a preliminary survey with twelve qualified hairdressers. The result showed that this represented a very high level of reliability on a five-point scale of discomfort for twelve body regions (Cronbach's alpha = 0.95). The result has been published in the International Association of Societies of Design Research (Fang *et al.*, 2007).

Next, in order to enhance the readability of the questionnaire, a modified version using illustrations of the left and right limbs was adopted. A picture showing these ten body regions of the upper limb along with the use of a five-point Likert scale was provided. The modified questionnaire was offered to two hundred and twenty professional hairdressers randomly selected from twenty-six different hair salons, categorised into six different hair-salon companies in Taiwan. The results also showed a very high level of reliability on a five-point scale of discomfort for ten body regions (Cronbach's alpha = 0.946).

7.2.2. Postural analysis on upper limb regions

Chapter 5 used qualitative video recordings and static photographs to support the quantitative findings of the questionnaire survey, as a part of the systematic evaluation procedure for the ergonomics intervention training. Based on the video recording of 12 professional hairdressers' postures, a total of 129 photos of the most risky postures were selected of which 21 were retained as representative photos for the RULA analysis. They were described and illustrated with different coloured labels representing the associated critical level. As a result, the risk of experiencing WMSDs with the right limb is greater than for the left limb. Furthermore, three out of the top critical overall scores associated with risky techniques are associated with hair-washing in the washbasin area, hair-straightening and hair-blow-waving, which are similar to the findings of the questionnaire survey. These critical risk postures of hairdressing techniques are then recommended for the implementation of the ergonomics training intervention programme described in Chapter 6.

7.2.3. 3D motion analysis and the task cycle graph

In Chapter 6, a six-camera 3D motion system was employed to validate the effectiveness of the ergonomics training intervention programme as the final stage of the systematic evaluation approach with six professional hairdressers. The study consists of pre and post tests to compare the motion differences that could confirm whether the training programme had affected the working posture positively or negatively.

In order to increase the validity of the study, both tests were undertaken at the 3D Motion Laboratory in the Department of Occupational Therapy, National Cheng Kung University, Taiwan. All experimental procedures were managed by a professional ergonomist - Assistant Professor Li-Chieh Kuo - and 3 Masters students in the Department of Occupational Therapy. The six-camera 3D motion analysis system used in this study, which was developed by Motion Analysis Corporation, Santa Rosa CA, provides objective data based on a calibration of 1/1M° of angle.

The study also validates the usefulness of the task cycle analysis and the associated task cycle graph. These task cycle graphs are particularly useful to demonstrate the joints during each task and to identify the awkward postures. The task cycle graph for the study of a complex hairdressing task can also be used to support the statistical analysis of the results; through the use of the task cycle graph, the change in the body movement over the normalized task cycle duration can be seen clearly. Thus, it is strongly recommended that the use of conventional statistical analysis and the task cycle graph should be combined for the study of complex hairdressing techniques because the task cycle graph can provide a qualitative explanation of the joint movement during the functional task.

7.3. The work-related musculoskeletal disorders associated with risk factors

This research emphasises that the ergonomics may be summarized in the principle of the user-centred framework and has to consider all relevant factors such as comfort, health and safety. Moreover, this research explores the relationship between the hairdressing job, its techniques, job description and working postures. This implies a dynamic working posture to utilize various body regions skilfully with various related equipment. If the awkward working posture occurs whilst performing the daily job, the discomfort is then cumulative and results in WMSDs in specific body regions.

Based on this research, it is possible to update the theoretical development cycle of work-related musculoskeletal disorders by the risk factors summarized in the following sections:

7.3.1. Hairdressing techniques

Based on the questionnaire survey, this research has made a contribution to the hairdressing industry in Taiwan by linking discomfort in specific body regions with particular hairdressing techniques. Furthermore, hair-washing, blow-drying and hair-cutting techniques were in most need of improvement as the result found that these techniques cause the most serious discomfort in the lower back, right-shoulder and neck.

7.3.2. Gender

This research highlight that the females felt more discomfort in their body regions than the males but not significantly so ($p>0.05$), except for neck discomfort where gender was a significant factor ($p < 0.05$).

7.3.3. Age

Regarding the effect of age, the overall discomfort level in the left hand/finger and right forearm was found to be significant. Thus the workload might cause the discomfort in specific body regions, in addition, ageing could have an effect on the muscle activity and kinematic function. Nevertheless, further investigation needs to be undertaken using a quantitative method to validate the relation between the techniques and risk factors for the working postures of hairdressers in Taiwan.

7.3.4. Job levels

This research highlights that the overall discomfort level in body regions and trouble due to WMSDs are not significantly different in five job levels ($p>0.05$). Therefore, this research suggests that the higher-level jobs did not significantly increase workload.

7.3.5. Others

Despite the tools and equipment being excluded owing to the time limitations of a PhD study, the study confirms that no significant relationship exists between the discomfort in body regions and work experience, weekly working days, working hours, working hours spent standing and the frequency of taking a break. However, the effect of the daily working hours on the discomfort in various body regions is a question that remains unanswered. The average working hours per day was 11.39. Although the

Pearson chi-square test indicated that the overall discomfort level in body regions is not significantly different in the working hours categories ($p>0.05$), the Pearson chi-square test indicated that the long working hours significantly increase the rate of sickness leave ($p<0.05$). Over 40% of participants who worked over 11 hours per day reported having sick leave due to work-related musculoskeletal disorders. The result highlights the urgent need to reduce the working hours to an official standard, say eight hours per working day.

Moreover, the research discovers that the number of participants who complained about discomfort affecting their daily life was significantly different in the six hair-salon companies ($p<0.05$), it is suggested that further investigation into the differences between these hair-salon companies should be made in terms of the administrative system and working environment.

7.4. Effectiveness of the ergonomics training programme

7.4.1. Introduction

The outcome of this research has provided a validated, ergonomics training programme which may benefit the trainee hairdressers in the educational system in Taiwan. The research emphasized that ergonomics should form part of the education of hairdressers since it is clear that there is a relationship between working postures and WMSDs in various body regions. The triangulation between working postures, techniques, discomfort and intervention (i.e. which can be referred to as job performance) is illustrated in Figure 3.1:

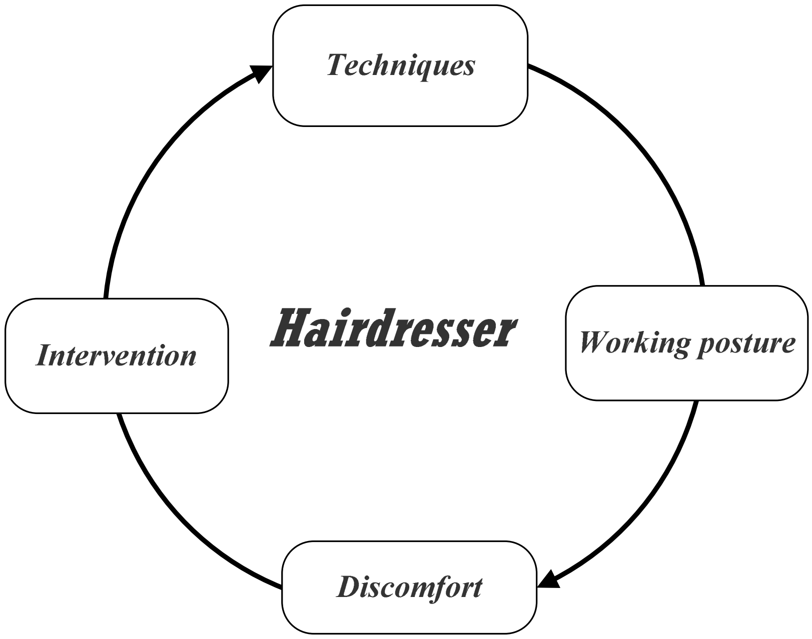

Figure 3.1. Triangulation between postures, techniques, discomfort and intervention.

7.4.2. Techniques

Techniques could refer to the following factors: repetitions, working postures, force, durations, psychosocial factors, individual differences and interpersonal skill. Most of these factors are related to the job performance.

Hairdressers are artistic as they seek to design a hairstyle after discussions with their clients. However, when starting to perform the necessary hairdressing techniques, they need to move their body to fit the height of the washbasin and adjust the styling chair to fit the length of a client's hair when using hair cutting or blow-drying or perming techniques. Thus, WMSDs are known in the hairdressing industry and could be caused by hairdressers experiencing the need to change the repetition and duration of their body movements and positions as they perform the techniques required to meet the client's needs.

7.4.3. Working posture

The poor posture and body motion might lead to local mechanical stress on the muscles, ligaments and joints, resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system. In turn, this could generate discomfort in particular body regions cumulatively. This is because, when maintaining a posture, the joints must be kept in a neutral position with the limbs, as far as possible, close to the body, thus enabling the muscles to deliver the greatest force.

7.4.4. Discomfort

Poor posture and movement can lead to local mechanical stress on the muscles, ligaments and joints, resulting in complaints of the neck, back, shoulder, wrist and other parts of the musculoskeletal system. This is because of the positions involved in maintaining a posture, as outlined above.

If hairdressers suffer musculoskeletal discomfort, injury and harm, this can mean not only decreased job performance and lower productivity, but also increased time off work and early retirement from this profession.

7.4.5. Intervention

The proposed ergonomics training programme was taught to educate hairdressers about the relationship between the job, the techniques, the job description and the working posture.

There are various forms of discomfort in body regions discovered from the research findings. However, as hairdressers work in different ways and use different techniques, the ways to decrease this discomfort whilst at the same time identifying the most important points to improve their techniques of posture and movement without detriment to the look of the hairstyle are an important problem.

Thus, this research aimed to educate hairdressers about how to maintain joint angles minimized to approach zero or a neutral posture for their upper limbs thereby moving towards a more neutral posture during the performance of the high-risk techniques and working postures. The programme consisted of the two-day lecture (weeks 2 and 3) and group study (weeks 4 to 15). The pilot test took place in week 1 and the evaluation test in week 16, after which the result of the comparison of the difference between the two tests validates the effectiveness of the ergonomics training on the improvement of the awkward working postures, using the 3D motion analysis and the task cycle graph. Such measurement of the motion requirements of the upper extremities during hair-blow-waving and hair-straightening techniques has several different potential clinical applications.

Regardless of their underlying condition, hairdressers with limited upper limb function and skill performance can be studied using the 3D motion analysis protocol proposed in this research. Thus, the same protocol can be recommended for various hairdressing techniques in the future, such as hair-cutting and hair-perming.

7.4.6. Moving theory into practice

In order to disseminate the intervention to the hairdressing industry, it requires the efforts and dedication from the Ministry of Labour, hairdressing companies, hair salons and college training systems. For instance, as upper limb and lower back pain has resulted in many claims for compensation from Taiwanese hairdressers, the development by the Ministry of Labour of a guide-book of health and safety in the hairdressing industry will be needed. Furthermore, a manual of WMSDs in the hairdressing industry relating to the safe working postures and the use of equipment and tools needs to be developed for trainers and educators in both hair salons and college training systems. Furthermore, the long-term training scheme and its effectiveness needs to be further investigated in the future.

7.5. Critical hairdressing techniques identified from this research

The three most critical hairdressing techniques identified by this research are discussed in the following sections:

7.5.1. Hair washing in the washbasin area

Based on the postural analysis using RULA, the most critical technique was identified as hair washing in the washbasin area, coded B7 (see Figure 7.1).

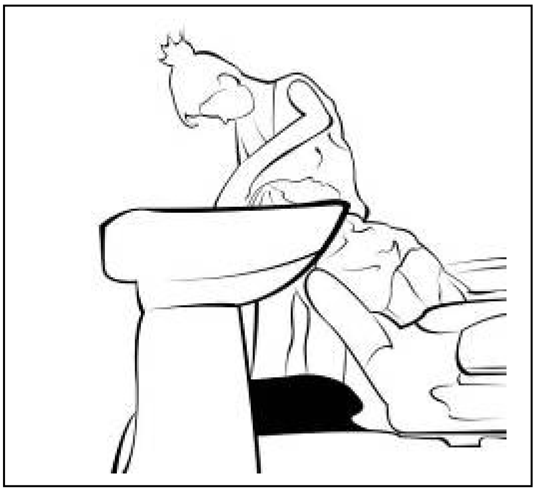

Figure 7.1. Hair Washing in the washbasin area.

From the observed posture, the hairdresser is bent forward at their trunk and neck which, as the evidence resulting from questionnaire indicates, produces the discomfort in the hairdresser's neck and lower back. The lower back pain is related to the working technique of hair-washing used by Taiwanese hairdressers. This agrees with the questionnaire survey.

Owing to the working environment being an essential factor that causes discomfort in the lower back, further study of the effect of the ergonomics training on the improvement of the awkward working postures involved in hair-washing techniques in the washbasin area is required.

7.5.2. Hair blow-waving with a blow-dryer

Based on the postural analysis using RULA and the motion analysis, the second most critical technique is coded D6 (see Figure 7.2), which is hair blow-waving with a blow-dryer.

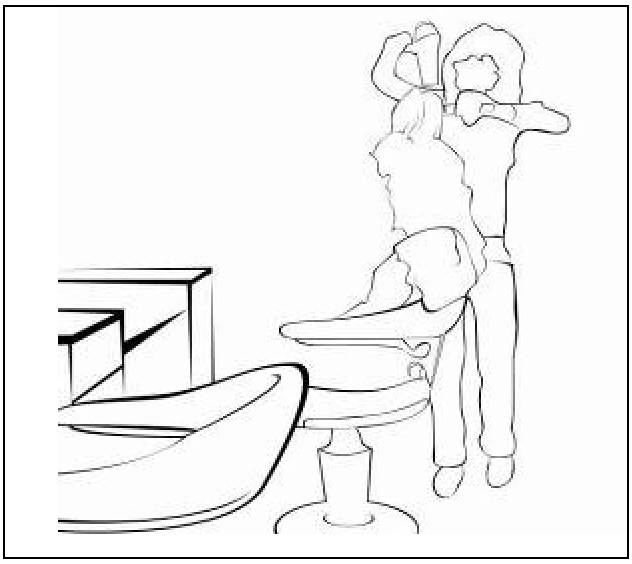

Figure 7.2. Hair blow-waving with a blow-dryer.

From the observed posture, the dryer was held at a constant height with static muscles for an undesirable length of time, bending and twisting the back to see the section and using the pistol grip of the dryer all the time. The upper limb was raised between 60^{o} to 90^{o} for blow-drying the top of the head repetitively.

In this research, the ergonomics training programme for the hair-blow-waving technique was given to three participants and proved to be a success. For instance, 80% of the directional joint ROMs were improved significantly with the new hair-blow-waving technique. Furthermore, it also reveals that the elbow flexion could be the most difficult joint ROM to be studied and improved for the hair-blow-waving technique. This is because the elbow is located behind the manikin-head where the 3D motion camera could not capture its motion. Such measurement of the motion requirements of the upper extremity during the hair-blow-waving technique has several different potential clinical applications.

7.5.3. Hair-straightening with a hair-straightening iron

Based on the postural analysis using RULA and the motion analysis, the third critical technique in terms of the RULA overall score for the right limb was identified as hair-straightening over the top of head with a hair-straightening iron, coded D6 (see Figure 7.3).

Figure 7.3. Hair-straightening with a hair-straightening iron.

From the observed posture, the straightening iron is held and gripped for a section of hair, and the right upper limb is raised up to 90^{o} for gripping section of hair on the top of the head. In this technique, straightening irons are designed to temporarily straighten hair to produce straight or flattened results. From the RULA analysis for the right limb, straightening hair in a sitting position came out as the third most likely of the hairdressing techniques to cause bodily discomfort.

In this research, three participants took part in the ergonomics training programme. This programme for the hair-straightening technique has been a success. For instance, 90% of the directional joint ROMs were improved significantly for the hair-straightening technique.

Moreover, it was discovered that the shoulder abduction movement during the hair-straightening technique is the most difficult to improve compared with the other joint ROMs. This is because the hair-straightening activity requires the whole arm to pull the hair-straightening iron. It can be expected that if the other joint ROMs are reduced, the shoulder abduction will increase accordingly. Thus, this study suggests that risk prevention must take place using the ergonomics training programme and be combined with design innovations for the conventional hair-straightening iron. Such measurement of the motion requirements of the upper extremity during hair-straightening techniques has several different potential clinical applications.

7.6. The advantages and disadvantages of 3D motion analysis

7.6.1. The advantages of using 3D motion analysis

It is strongly recommended that the use of conventional statistical analysis and the task cycle graph should be combined for the study of complex hairdressing techniques because the task cycle graph can support the statistical analysis of the data to provide a qualitative explanation of the joint movement during the functional technique. For instance, in the case of the right shoulder flexion during the functional work of hair-blow-waving, the task cycle graph demonstrates that the overall right shoulder flexion after the ergonomics training is clearly reduced.

7.6.2. The disadvantages of using 3D motion analysis

As mentioned in the research limitations, the raw data of the 3D kinematics values used in this study could be blocked by the manikin-head, which causes sudden shifts. In this study, since the advanced filtering algorithm for the statistical smoothness characteristics of the camera data was not employed, the raw data of the 3D kinematics values with sudden shifts can be seen from the task cycle graph. Thus, since the elbow movement is quite difficult to observe by the optical-based 3D motion analysis used in this study, a human operator's judgment is still required as the ultimate solution for removing the resulting outliers (He and Tian, 1998). Under such conditions, the sensor-based motion analysis technique might be an alternative for future studies.

Chapter Eight: Conclusion and Further Recommendations

8.1. Summary of the findings of the research

This research focuses on an investigation into the status of WMSDs in the hairdressing industry in Taiwan. The outcome of this research will provide a validated, user-centred WMSDs prevention framework that benefits both trainee hairdressers and the educational system in Taiwan. The relationship between working postures and WMSDs in the various body regions where poor posture and movement can lead to local mechanical stress on the muscles, ligaments and joints, resulting in complaints of the neck, back, shoulder and wrist, as well as other parts of the musculoskeletal system, is discussed.

8.2. Main contribution of this research

The purposes of the research are to investigate the status of WMSDs cases from Taiwanese hairdressers; and to develop user-centred strategic solutions to prevent Taiwanese hairdressers from accumulating musculoskeletal disorders, especially for those newcomers to the profession. This research has provided a WMSDs prevention framework as the strategic solution for a continuing improvement of the awkward working postures during the functional activities of the various daily hairdressing techniques. The areas of the study have involved a sequence of investigations into the status of WMSDs for hairdressers in Taiwan as a first step leading towards their prevention. This has included the use of hairdresser-oriented questionnaires to discover a wider range of the risk factors for WMSDs among Taiwanese hairdressers, and the use of a validated, on-line, RULA tool to identify critical hairdressing working postures. The most critical hairdressing working postures have been identified by the investigation and improved by the implementation of an ergonomics training programme. The effectiveness of the training was validated using 3D Motion Analysis based on the comparison of awkward movements between the pre- and post-test. Thus, the findings of this research are described in the following sections as original contributions to the field.

8.2.1. Usefulness of 3D motion analysis and the task cycle graph

This research aims to turn the theory of assessment exposure in hairdressing techniques into suitable assessment methods, not only to identify the risk factors that lead to WMSDs, but also to explain the causes of discomfort to those hairdressers who are not familiar with ergonomics knowledge. The use of observation and sEMG as risk assessment methods in this research, which are typically used for the study of hairdressing work in the recent studies, was considered. However, hairdressers' needs might be completely different or they might misunderstand the ergonomists intervention. Such confusions need to be considered in the future development of the exposure assessment methods that are able to combine both the different points of view.

In this research, the study validates the usefulness of the task cycle analysis and the associated task cycle graph, which provides a better understanding of the causal relationship between posture, technique and discomfort. For instance, 3D motion analysis can be used to reveal the relationships between the joint ROMs and the risky hairdressing techniques that are associated with awkward working postures that can lead to the development of discomfort in some body regions. Furthermore, the task cycle graph can helps to illustrate and identify the awkward postures. Through the use of the task cycle graph, the change in the body movement over the normalized task cycle duration can be seen clearly. The task cycle graph for the study of a complex hairdressing task can also be used to support the statistical analysis of the results; through the use of the task cycle graph, the change in the body movement over the normalized task cycle duration can be seen clearly. Thus, it is strongly recommended that the use of conventional statistical analysis and the task cycle graph should be combined for the study of complex hairdressing techniques because the task cycle graph can provide a qualitative explanation of the joint movement during the functional task.

8.2.2. Risk exploration using the proposed hairdresser-oriented musculoskeletal questionnaire surveys

Chapter 4 aimed to design a hairdresser orientated musculoskeletal questionnaire as a pilot study. The pilot study was an initial investigation of the status of twelve professional hairdressers through the use of a revised Nordic questionnaire. The findings of the pilot study were published at an international conference IASDR 2007 (Fang *et al.*, 2007).

In Chapter 4, a formal study (n=220) followed the pilot study (n=12); a revised hairdressing musculoskeletal questionnaire was designed by adding the questions about the relationship between hairdressing techniques and the discomfort level in the upper limbs and the trunk with a much larger number of participants in Taiwan. As a result, the techniques of hair-washing, blow-drying and hair-cutting were found to be associated with the highest overall discomfort levels in the lower back, right-shoulder and neck, these techniques were recommended for further investigation in a follow-up study.

8.2.3. Risk identification using direct observation with the on-line RULA tool

In Chapter 5, in order to identify the necessary hairdressing techniques, the observation method using video recording was employed to observe hairdresser's daily techniques, as recommended by the previous study with twelve participants. An on-line RULA tool was used to evaluate the risk level of hairdressing techniques and associated working postures illustrated from static photos. As a result, the 21 most risky postures were identified from these daily hairdressing techniques, three of these were found to be associated with hair-washing in the washbasin area, hair-straightening and hair-blow-waving. The findings are consistent with the questionnaire survey. Both hair-blow-waving and hair-straightening techniques over the top of the manikin-head are recommended for further study.

8.2.4. The success of the ergonomics training on risk prevention with complex hairdressing techniques

In Chapter 6, an ergonomics training programme was integrated into a hairdressing course within an academic semester (i.e. sixteen weeks) at the Department of Styling & Cosmetology in Tainan University of Technology, Taiwan. The pre- and post-tests were conducted before and after a hairdressing course to identify any improvement in awkward postures. The 3D motion analysis was employed to quantitatively record the 3D body movement of hair-blow-waving and hair-straightening techniques over the top of the manikin-head for 6 participants (i.e. 3 with hair-blow-waving techniques and 3 with hair-straightening techniques). The analysis indicates the success of the programme for both hair-blow-waving and hair-straightening techniques. For instance, 90% of the directional joint ROMs were improved significantly with hair-straightening, followed by 80% for hair-blow-waving. The result findings were discussed and later published at an international conference, IASDR 2009 (Chen *et al.*, 2009).

Further findings were: firstly, it was revealed that the elbow flexion could be the most difficult joint ROM to be studied and improved for the hair-blow-waving technique. This is because the elbow is located around the manikin-head where the 3D motion camera could not capture its motion. Secondly, it was discovered that the shoulder abduction movement during the hair-straightening technique is the most difficult to improve compared with the shoulder abduction. Thus, this study suggests that risk prevention must become part of the ergonomics training programme and be combined with a design innovation for the conventional hair-straightening iron.

8.3. Recommendations

8.3.1. For the Ministry of Labour and hairdressing companies in Taiwan

As upper limb and lower back pain has resulted in many claims for compensation from Taiwanese hairdressers, the development by the Ministry of Labour of a guide-book of health and safety in the hairdressing industry will be needed. It should focus on risk factors that lead to WMSDs in the working environment as well as the facilities, equipment and tools used; especially for the hair washbasin area and styling chairs, stools and trolleys. Furthermore, a standard WMSDs prevention system for hairdressers, salon managers, supervisors and salon owners can be expected to provide a basis for the prevention of WMSDs so as to ensure a longer and healthier career for hairdressers.

8.3.2. For the training and education system

A manual of WMSDs in the hairdressing industry relating to the safe working postures and the use of equipment and tools needs to be developed for trainers and educators in both hair salons and college training systems. Furthermore, the long-term training scheme and its effectiveness needs to be further investigated in the future.

8.3.3. For future research

1. In order to obtain a more reliable set of results in ergonomics training effectiveness, further work needs to be carried out based on this research and trials would need to involve larger subject groups. In particular, the questionnaire survey should be closely monitored with a large subject group on a more regular basis, i.e. quarterly or annually.
2. This research focuses on working postures only; to examine the effects of repetition, duration, and the force of the movements found in hairdressers' daily tasks as work-related musculoskeletal disorders risk factors, further risk identification work will need to be carried out in the future.
3. Since the time and experimental tools were limited, more hairdressing techniques may have the potential to cause work-related injuries, which will need to be identified as part of any future research.
4. Sensor-based 3D motion analysis might be an alternative method for future study based on the framework used in this research since the elbow is very difficult to observe using optical-based 3D motion analysis.
5. Based on the postural analysis using RULA, the most critical technique was identified as hair washing in the washbasin area. From the observed posture, the hairdresser is bent forward at their trunk and neck which, as the evidence resulting from questionnaire indicates, produces the discomfort in the hairdresser's neck and lower back, further study of the ergonomics design of the washing station is required.

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Appendix A: Hairdresser's Musculoskeletal Questionnaire (Chinese Version I)

美髮從業人員肌肉骨骼傷害問卷

美髮從業人員您好:
此份問卷是一種檢視勞工作業之姿勢、動作等，以減少勞工在作業時之肌肉骨骼傷害（如腰酸、背痛等）現象，因此設計了這份問卷。您是我們抽樣的對象，請您能配合並詳細填寫這份問卷，供我們作為研究之用。本問卷資料為統計之用，並不作任何行政處理，請您放心填寫。謝謝您！

研究者: 方曉羚
Art & Design Faculty, De Montfort University, UK

◆ 第一部份 個人基本資料 ◆

1.填表日期：________年________月________日

2.服務機構：________________________公司___________縣市

3.職稱：______(以下擇一回答)
(1)助理 (2)準師 (3) 1~5年髮型設計師 (4) 5年以上髮型設計師

4.性別：□男 □女

5.出生年月日：________年________月________日

6.身高：________公分

7.體重：________公斤

8.您經常運動嗎？
□不常 □偶爾 □至少每星期一次

10.您有抽煙的習慣嗎？
□沒有 □偶爾抽 □常抽，平均每天抽________根

11.您平時做事習慣使用哪一隻手？
□右手 □左手

◆ 第二部分 工作狀況 ◆

1. 您從事美髮工作已有多久? ______年______月
2. 您一天工作幾小時? ______小時, 一週工作______天
3. 您的工作是否有安排工作時間?
□沒有 □有, 一天休息________次, 一次休息_______分鐘
4. 您工作的類型是: (可複選)

(1) □洗髮	(2) □剪髮	(3) □燙捲頭髮	(4) □燙直頭髮
(5) □染髮	(6) □吹風整型	(7) □搬運物料	(8) □其他

5. 您使用的工具有哪些?

(1) □剪刀	(2) □梳子	(3) □ 捲棒	(4) □ 離子夾
(5) □洗頭水瓶	(6) □吹風機	(7) □ 削刀	
(8) □其他:			

◆ 第三部份 個人疾病史 ◆

1. 病史

A. 過去是否由醫師診斷出下列疾病 (請打勾)

疾病	a. 無	b. 有	附註(哪年發現此病)
(1)肌腱炎			
(2)關節炎			
(3)下背痛			
(4)腱鞘炎			
(5)網球肘			
(6)腕隧道症候群			
(7)其他骨骼肌肉疾病			

2. 自覺症狀

B. 請問您在最近一年內,身體各部位有無不舒服的情況出現? (請打勾)

不舒服的部位	沒有	有	不舒服的感覺 (可複選)					不舒服的程度				
			a. 關節痠痛	b. 肌肉紅腫	c. 發麻刺痛	d. 肌肉萎縮	e. 其他	i. 沒關係	ii. 輕微	iii. 不舒服	iv. 非常不適	v. 嚴重
(1) 脖子												
(2) 肩膀												
(3) 上手臂												
(4) 前手臂												
(5) 手指及手腕												
(6) 手肘												
(7) 上背												
(8) 下背及腰												
(9) 大腿												
(10) 膝關節												
(11) 小腿												
(12) 腳裸及足												

C. 您認為這些不適的症狀與目前的工作相關嗎?

□ (1) 全因工作造成 □ (2) 一部分與工作有關 □ (3) 與工作無關

D. 這些症狀對你的影響為何?

□ (1) 不影響生活及工作 □ (2) 稍微影響工作 □ (3)工作能力明顯降低
□ (4) 工作及生活皆受影響 □ (5) 完全不能工作

E. 您是否因為這些症狀而請假休養? □ (1) 沒有 □ (2) 有,約請過_____次假

F. 有因此住院過嗎? □(1)沒有 □ (2)有

Appendix B: Hairdresser's Musculoskeletal Questionnaire (English Version I)

Part A: Background Information

1. Date： ________Year________Month________Day

2. Location： __________________________Company_____________City

3. Job title： ______(please choose one below)
(1) up to 1 year junior technician
(2) 1 to 2 years senior technician
(3) 1~5 years experienced junior hairdresser
(4) over 5 years experienced senior hairdresser

4. Gender：☐Male ☐Female

5. Date of Birthday： ________Year________Month______ Day

6. Height： ________cm

7. Weight： ________Kg

8.Do you do exercise？

☐Never ☐Sometime ☐At least once a week

10.Do you smoke？

☐No ☐Sometime ☐Often

11. Are you right-handed or left-handed user?

☐Right ☐Left

Part B: Occupation States

1. How long have you been working as a hairdresser? ______Year______Month

2. How many hours of a week do you work? ______Hour,
   How many days of a week, _______Day

3. Do you take breaks during your job per day?

   ☐ No ☐Yes

   How many time of a day________, How long do you take a break each time_______ minutes

4. Choose hairdressing tasks that you perform in a hair salon: (multiple selection)

☐ Hair washing	☐ Hair cutting	☐Hair perming	☐ Hair straightening
☐ Hair colouring	☐ Hair blow-drying	☐Carry products	☐others

5. Which tool do you use for hairdressing task?

☐Scissor	☐Comb	☐ Curler	☐ Straightener
☐Bottle	☐Blow-dryer	☐ Razor	
☐Others			

Part C: Symptoms found by Doctors in the past

Symptoms	No	Yes	When(if you answer "Yes")
(1) Tendinitis			
(2) Arthritis			
(3) Lower back pain			
(4) Tenosynovitis			
(5) Tennis elbow			
(6) Carpal tunnel syndrome, CTS			
(7) Other symptoms related with MSDs?			

Part D. Discomfort of body region

Do you feel discomfort in the past year?

Regions of discomfort	No	Yes	Part E. Symptoms of Discomfort (Multi-Selection)					Part F. Levels of discomfort				
			Arthritic	Inflammation	Numbness and needles	Atrophy	Others	Non discomfort	Discomfort	Mild	Moderate	Severe
(1) Neck												
(2) Shoulder												
(3) Upper arms												
(4) Lower arms												
(5) Wrists and fingers												
(6) Elbow												
(7) Upper back												
(8) Lower back												
(9) Upper legs												
(10) Knees												
(11) Lower legs												
(12) Feet												

Part G. Effects and Causes of Discomfort

1. Do you think that the causes of discomfort are related to your job?

   ☐ (1) Fully agree, ☐ (2) partly agree, ☐ (3) it is nothing to do with my job

2. What are causes of discomfort to your hairdressing work?

   ☐ (1) no affect at all ☐ (2) silly affects ☐ (3) have effected my performance

   ☐ (4) have effected my daily life ☐ (5) Have terminated my job

3. Have you been absent caused by these discomfort?? ☐ (1) No ☐ (2) Yes,
   How many times since then?: _____time.

4. Have you ever been to the hospital because of these discomfort? ☐(1)No ☐ (2)Yes

Appendix C: Hairdresser's Musculoskeletal Questionnaire (Chinese Version II)

美髮從業人員工作任務與姿勢及肌肉骨骼傷害問卷

美髮從業人員您好：
此份問卷是一種檢視美髮工作人員之姿勢、操作、工具使用與肌肉骨骼傷害的關係，以減少美髮師在工作時之肌肉骨骼傷害（如腰酸、背痛等）的問題。您是我們抽樣的對象，請您能配合並詳細填寫這份問卷，供我們作為研究之用。另外，請填入您的真實姓名與聯絡電話，因為或許我們的研究需要您日後進一步的協助。請放心，本問卷資料為統計之用，並不作任何行政處理，請您放心填寫。謝謝您！

英國De Montfort大學 設計與藝術學院
研究者: 方曉羚 (2007年7月.18日)

◆答題方式◆

1. 如遇選擇題，請您於適當答案的方塊上 □ 打✓；
2. 如遇不舒服程度之題目，請您於適當答案的*感情符號*上打✓：
   沒有、一點點、不舒服、非常不適、很痛苦

◆ 第一部份 個人基本資料 ◆

1. 填表日期：_______年_______月_______日
2. 服務機構：_________________________公司________________縣市
3. 姓名：________________
4. 聯絡電話：公司________________ 手機________________
5. 職稱：□1年以下助理手 □1~2年助理 □準師
   □ 1~5年髮型設計師 □ 5年以上髮型設計師
6. 性別：□男 □女
7. 年齡：_______歲
8. 您平時做事習慣使用哪一隻手？ □右手 □左手

◆ 第二部分 工作狀況 ◆

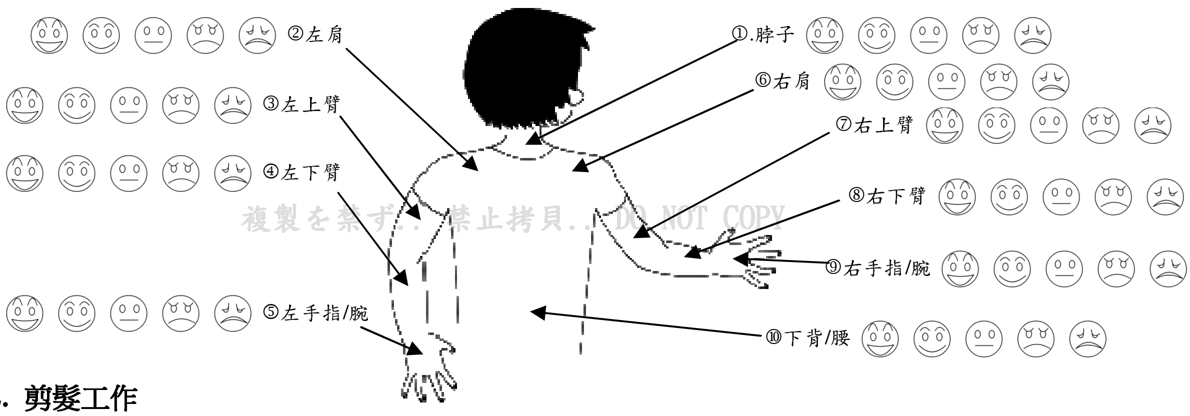
1. 您從事美髮工作已有多久（包括以前所任職的髮廊）？ ______年______月
2. 您平均一週工作幾天？ _______天
3. 您平均一天工作幾小時？ ______小時
4. 您平均一天工作時的站立時間？ ______小時
5. 您每天的工作是否有安排休息時間？ □ 沒有 □ 有 □ 要看情況，請舉例：
   ____
6. 您工作時最常採用的工作姿勢為 ①站立、②坐著、③蹲著或④跪著？ 請依序排列之：
   ____
7. 您平時工作時習慣使用哪一隻手持<u>吹風機</u>？ □右手 □左手
8. 您平時工作時習慣使用哪一隻手持<u>剪刀</u>？ □右手 □左手

◆　第三部份 自覺症狀與美髮從業人員工作的關係◆

1. 洗頭髮工作

(1). 您是否從事<u>洗頭髮</u>這項工作？（若回答無則不須回答第(2)與(3)題）　□無　□有

(2). 從事<u>洗頭髮</u>工作時，請問您身體各部位之不舒服程度？（如無不舒服請於☺打✓）



2. 剪髮工作

(1). 您是否從事<u>剪髮</u>這項工作？（若回答無則不須回答第(2)與(3)題）　□無　□有

(2). 從事<u>剪髮</u>工作時，請問您身體各部位之不舒服程度？（如無不舒服請於☺打✓）

①.脖子　　⑩下背/腰
②左肩　　⑥右肩
③左上臂　　⑦右上臂
④左下臂　　⑧右下臂
⑤左手指/腕　　⑨右手指/腕

3. 燙捲、燙直頭髮工作

(1). 您是否從事<u>燙捲、燙直頭髮</u>這項工作？（若回答無則不須回答第(2)與(3)題）　□無　□有

(2). 從事<u>燙捲、燙直頭髮</u>工作時，請問您身體各部位之不舒服程度？（如無不舒服請於☺打✓）

①.脖子　　⑩下背/腰
②左肩　　⑥右肩
③左上臂　　⑦右上臂
④左下臂　　⑧右下臂
⑤左手指/腕　　⑨右手指/腕

4. 染髮工作

(1). 您是否從事<u>染髮</u>這項工作？（若回答無則不須回答第(2)與(3)題）　□無　□有

(2). 從事<u>染髮</u>工作時，請問您身體各部位之不舒服程度（如無不舒服請於☺打✓）

①.脖子　　⑩下背/腰
②左肩　　⑥右肩
③左上臂　　⑦右上臂
④左下臂　　⑧右下臂
⑤左手指/腕　　⑨右手指/腕

5. 吹風造型工作

(1). 您是否從事吹風造型這項工作？（若回答無則不須回答第(2)與(3)題） ▫無 ▫有

(2). 從事吹風造型工作時，請問您身體各部位之不舒服程度？（如無不舒服請於打✓）

①.脖子	⑩下背/腰
②左肩	⑥右肩
③左上臂	⑦右上臂
④左下臂	⑧右下臂
⑤左手指/腕	⑨右手指/腕

6. 總體評估

(1). 請您回想一下，從事美髮工作，請問您身體各部位之不舒服程度？（如無請於打✓）

①.脖子	⑩下背/腰
②左肩	⑥右肩
③左上臂	⑦右上臂
④左下臂	⑧右下臂
⑤左手指/腕	⑨右手指/腕

(2). 如果改善工作動作可以降低不舒服程度，您最想改善的工作是
①洗髮、②剪髮、③燙捲燙直、④染髮或⑤吹風造型？ 請依序排列之：____________________

◆ 第四部份 病史 ◆

1. 您認為這些不舒服的症狀與目前的工作相關嗎？
   ▫與工作無關 ▫一部分與工作有關 ▫全因工作造成
2. 這些不舒服的症狀對您的影響為何？
   ▫不影響生活及工作 ▫稍微影響工作 ▫工作能力明顯降低 ▫工作及生活皆受影響 ▫完全不能工作
3. 您是否因為這些不舒服的症狀而請假休養？ ▫沒有 ▫有

-全文完-

Appendix D: Hairdresser's Musculoskeletal Questionnaire (English Version II)

Part A: Background Information

Label	Value
Location	(1) Training centre (2) Hair salon
Job	(1) up to 1 year junior technician (2) 1 to 2 years senior technician (3) senior technician (4) 1~5 years experienced junior hairdresser (5) over 5 years experienced senior hairdresser
Gender	(0) female (1) male
Age	Years old
Are you right-handed or left-handed user?	(1) Right-handed user (2) Left-handed user

Part B: Occupation States

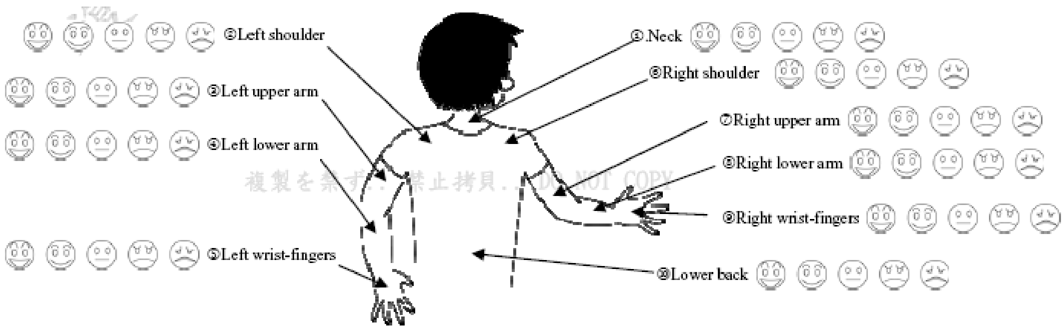
Label	Description
How long have you been working as a hairdresser?	Years(s) and month(s)
How many days do you work every week?	Day(s)
How many hours do you work every day?	Hour(s)
How many hours do you stand for the working day?	Hour(s)
Do you take breaks during your work?	(0) No, (1)Yes m in (eliminate "not sure")
Working posture. Which one is the most used working posture as you work?	(1) Stand (2) Sit (3) Squat your knees (4) Kneel down
Which hand do you use to hold a hairdryer as your custom?	(1) Right (2) Left
Which hand do you use to hold a scissor as your custom?	(1) Right (2) Left

Part C: Relation between self-awareness and hairdressing techniques

Part 1: Washing hair

(1) Do you perform washing hair? No or yes. If answer is “No” then go to the Part 2

(2) Has any discomfort occurred in part of your body regions when you are performing the washing hair task with a client?



Part 2: Hair cutting

(1) Do you perform hair cutting? No or yes. If answer is “No” then go to the Part 3

(2) Has any discomfort occurred in part of your body regions when you are performing hair cutting task with a client?

Part 3: Hair perming

(1) Do you perform hair perming? No or yes. If answer is “No” then go to the Part 4

(2) Has any discomfort occurred in part of your body regions when you are performing hair perming task with a client?

Part 4: Hair colouring

(1) Do you perform hair colouring? No or yes. If answer is “No” then go to the Part 5

(2) Has any discomfort occurred in part of your body regions when you are performing hair colouring task with a client?

①.Neck	⑩Lower back
②Left shoulder	⑥Right shoulder
③Left upper arm	⑦Right upper arm
④Left lower arm	⑧Right lower arm
⑤Left wrist-fingers	⑨Right wrist-fingers

Part 5: Hair blow-drying

(1) Do you perform hair blow-drying? No or yes. If answer is “No” then go to the Part 6

(2) Has any discomfort occurred in part of your body regions when you are performing hair blow-drying task with a client?

①.Neck	⑩Lower back
②Left shoulder	⑥Right shoulder
③Left upper arm	⑦Right upper arm
④Left lower arm	⑧Right lower arm
⑤Left wrist-fingers	⑨Right wrist-fingers

Part 6: Overall assessment

(1) As you are a hairdresser, have you ever occurred to feel discomfort during your work in a hair salon in your body regions?

①.Neck	⑩Lower back
②Left shoulder	⑥Right shoulder
③Left upper arm	⑦Right upper arm
④Left lower arm	⑧Right lower arm
⑤Left wrist-fingers	⑨Right wrist-fingers

(2) What do you think to decrease your discomfort if the task can be improved, 1.hair washing 2.hair cutting 3.hair perming 4.hair colouring 5.hair blow-drying? please prioritize in order :______________________

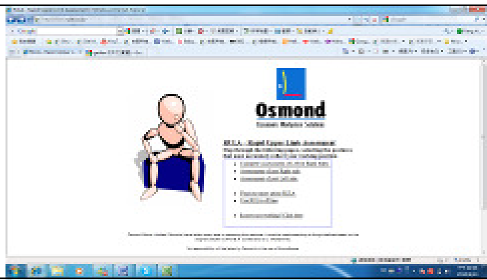
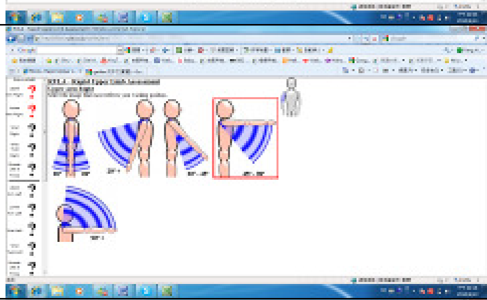
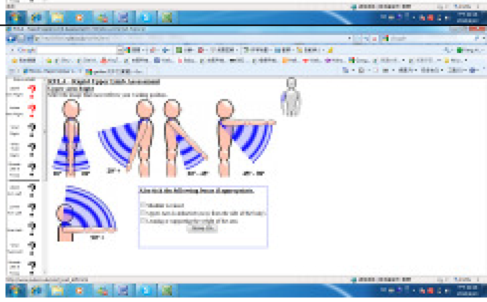
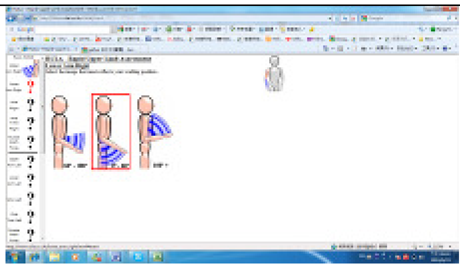
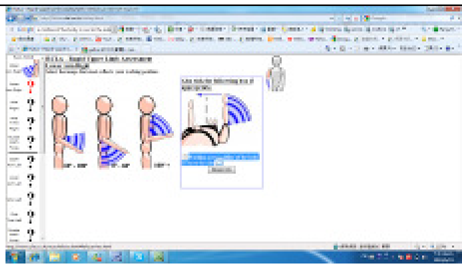
Part D. Effects and Causes of Discomfort

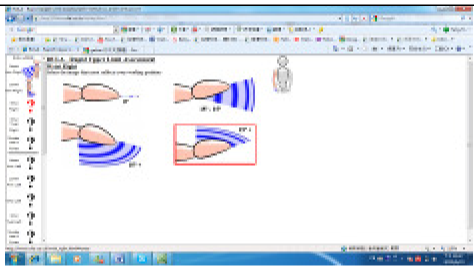
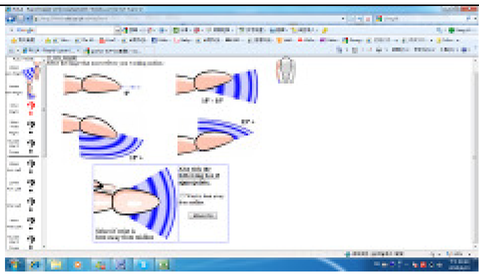
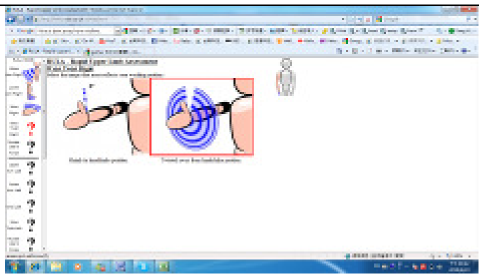
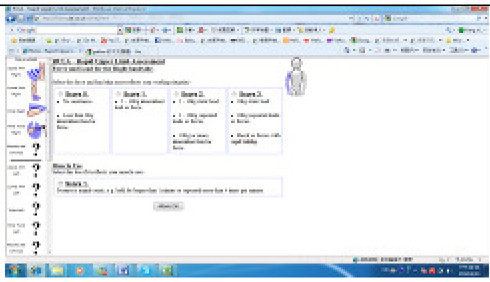
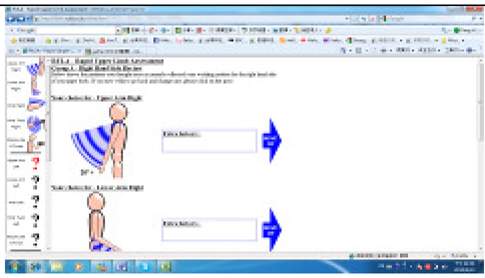
(1) Do you think that the causes of discomfort are related to your job?
1. Fully agree, 2. Partly agree, 3. It is nothing to do with my job.

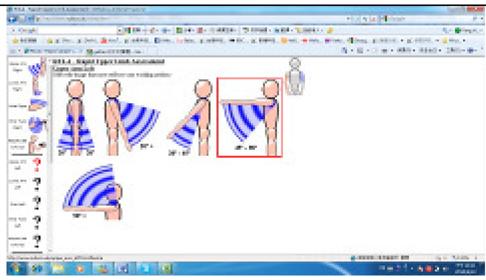
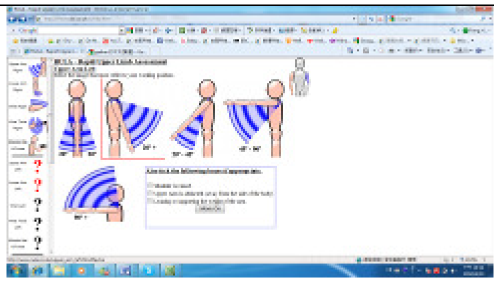
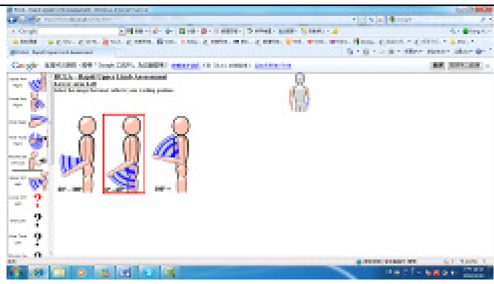
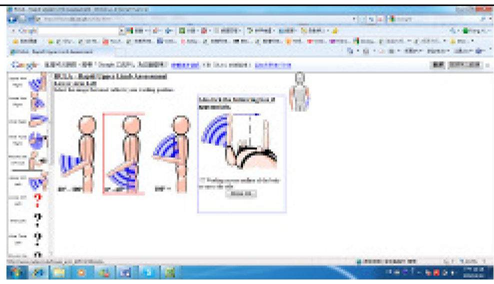
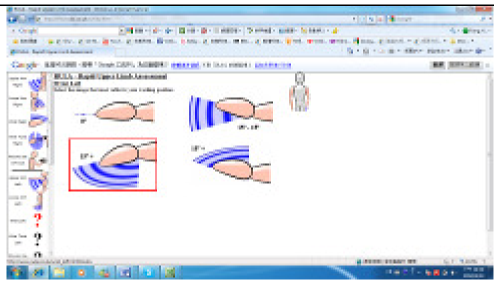
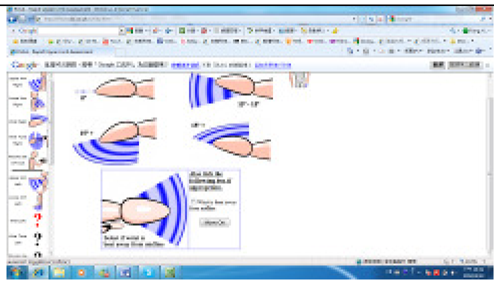
(2) What are causes of discomfort to your hairdressing work?
1. No effect at all 2. Silly effects 3. Have affected my performance
4. Have affected my daily life

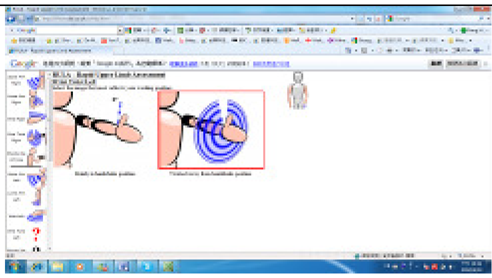
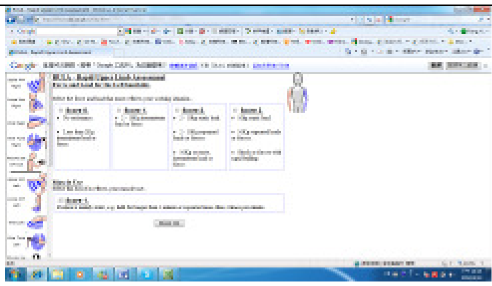
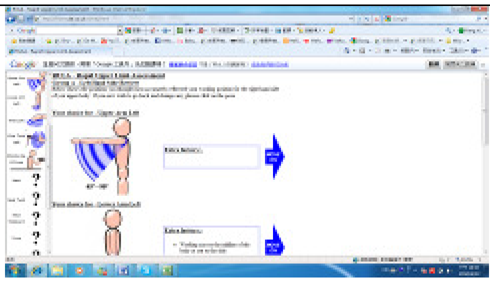
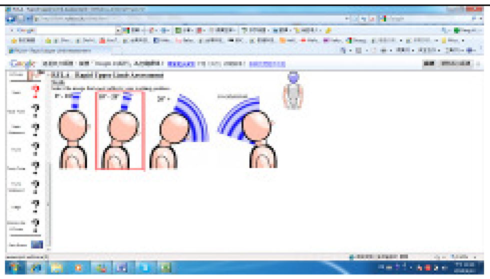
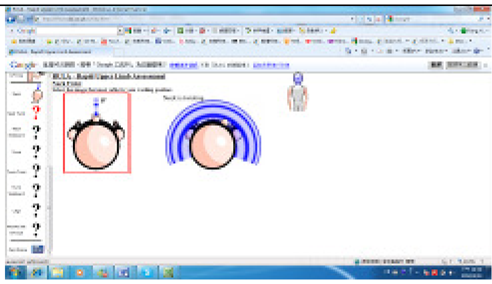
(3) Have you been absent caused of these discomfort?
1. No, 2. Yes.

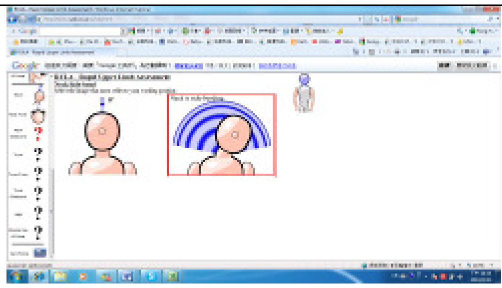
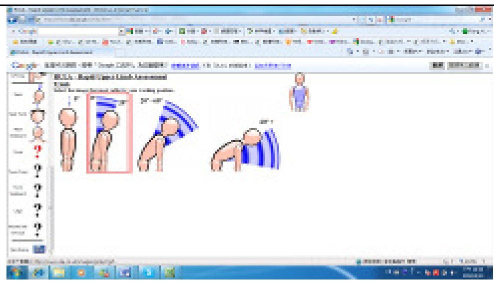
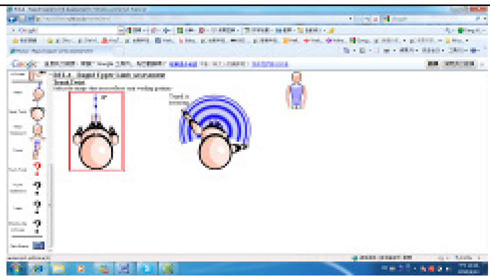
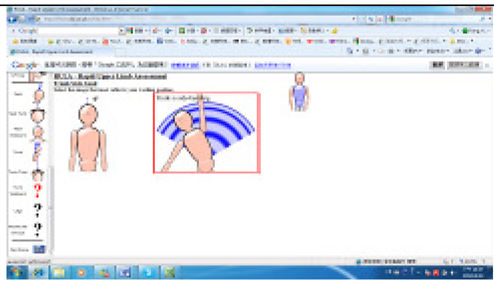
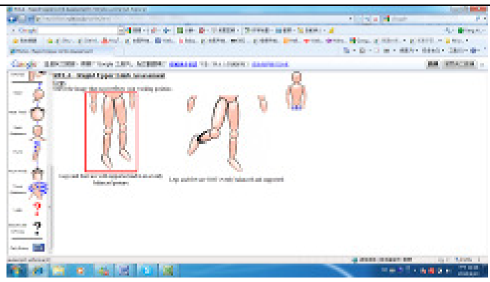
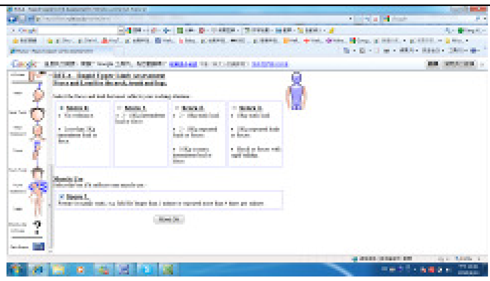
Appendix E: Scoring the posture step by step from on-line web-based RULA

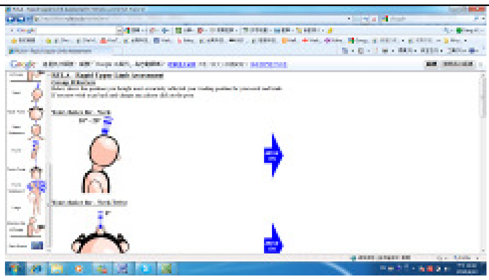
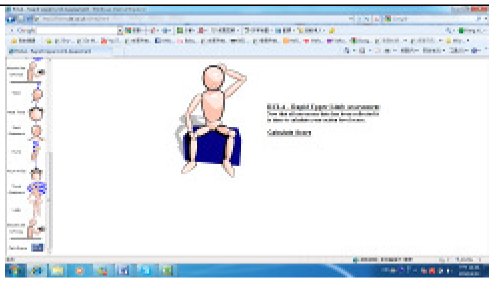
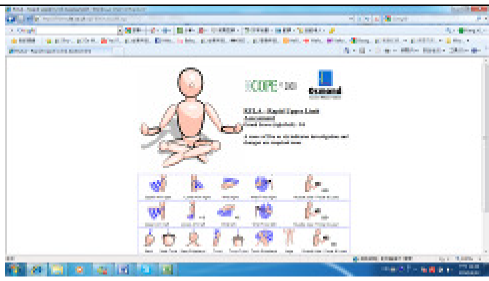
Step	Web-based RULA tool	Description
Page 1: Selecting the assessment upper limbs		There have 3 choices of assessment: 1. Completed assessment of Right/Left sides. 2. Assessment just Right side. 3. Assessment just Left side
Page 2: Selecting the posture(s) to assess: upper arm right		Select the image that most reflects your working position from right upper limb.
Page 3: Tick the posture(s) if appropriate for upper arm right		Information provided in 3 sections: 1. Shoulder is raised. 2. Upper Arm is abducted (away from the side of the body). 3. Leaning or supporting the weight of the arm.
Page 4: Moving on to assess lower arm right		Select the image that most reflects your working position from right lower limb.
Page 5: Tick the posture(s) if appropriate for lower arm right		Information provided one section: Working across midline of the body or out to the side

Step	Web-based RULA tool	Description
Page 6: Moving on to assess wrist right		Select the image that most reflects your working position from wrist right.
Page 7: Tick the posture(s) if appropriate for wrist right		Information provided one section: Wrist is bent away from midline.
Page 8: Moving on to assess wrist twist right		Select the image that most reflects your working position from wrist twist right.
Page 9: Selecting the 1. force and load for the right hand side; 2. muscle use		Information provided in 4 sections: 1. Score 0: Less than 2Kg intermittent load or force. 2. Score 1: 2 - 10Kg intermittent load or force. 3. Score 2: 2 - 10kg static load, repeated loads or forces and 10Kg or more, intermittent load or force. 4. Score 3: 10kg static load, repeated loads or forces and shock or forces with rapid buildup. For score 1 of muscle use: If posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per minute.
Page 10: Group A for right hand side review		If you satisfy the posture choose in the Group A (for right hand side), then tick move on to the left limb assessment.

Step	Web-based RULA tool	Description
Page 11: Selecting the posture(s) to assess: upper arm left		Select the image that most reflects your working position from left upper limb.
Page 12: Tick the posture(s) if appropriate for upper arm left		Information provided in 3 sections: 1. Shoulder is raised. 2. Upper Arm is abducted (away from the side of the body). 3. Leaning or supporting the weight of the arm.
Page 13: Moving on to assess lower arm left		Select the image that most reflects your working position from left lower limb.
Page 14: Tick the posture(s) if appropriate for lower arm left		Information provided one section: Working across midline of the body or out to the side
Page 15: Moving on to assess wrist left		Select the image that most reflects your working position from wrist left.
Page 16: Tick the posture(s) if appropriate for wrist left		Information provided one section: Wrist is bent away from midline.

Step	Web-based RULA tool	Description
Page 17: Moving on to assess wrist twist left		Select the image that most reflects your working position from wrist twist left.
Page 18: Selecting the 1. force and load for the right hand side; 2. muscle use		Information provided in 4 sections: 1. Score 0: Less than 2Kg intermittent load or force. 2. Score 1: 2 - 10Kg intermittent load or force. 3. Score 2: 2 - 10kg static load, repeated loads or forces and 10Kg or more, intermittent load or force. 4. Score 3: 10kg static load, repeated loads or forces and shock or forces with rapid buildup. For score 1 of muscle use: If posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per minute.
Page 19: Group B for left hand side review		If you satisfy the posture choose in the Group B (for left hand side), then tick move on to the neck, trunk and leg assessment.
Page 20: Selecting the posture(s) to assess: neck		Select the image that most reflects your working position from neck.
Page 21: Moving on to assess neck twist		Select the image that most reflects your working position from neck twist.

Step	Web-based RULA tool	Description
Page 22: Moving on to assess neck side-bend		Select the image that most reflects your working position from neck side-bend.
Page 23: Moving on to assess trunk bend forward		Select the image that most reflects your working position from trunk bend forward.
Page 24: Moving on to assess trunk twist		Select the image that most reflects your working position from trunk twist.
Page 25: Moving on to assess trunk side-bend		Select the image that most reflects your working position from trunk side-bend.
Page 26: Selecting the posture(s) to assess: legs		Information provided in 2 sections: 1. Legs and feet are well supported and in an evenly balanced posture. 2. Legs and feet are NOT evenly balanced and supported.
Page 27: Selecting the 1. force and load for the neck, trunk and legs; 2. muscle use		Information provided in 4 sections: 1. Score 0: Less than 2Kg intermittent load or force. 2. Score 1: 2 - 10Kg intermittent load or force. 3. Score 2: 2 - 10kg static load, repeated loads or forces and 10Kg or more,

Step	Web-based RULA tool	Description
		intermittent load or force. 4. Score 3: 10kg static load, repeated loads or forces and shock or forces with rapid buildup. For score 1 of muscle use: If posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per minute.
Page 28: Group B for neck, trunk and legs review		If you satisfy the posture choose in the Group B (for neck, trunk and legs), then tick move on to calculate score.
Page 29: Scoring		Click the calculation bottom.
Page 30: Overall score result		Overall score (right/left): x/x of Action Level will appear on the screen,that require an improvement will then be suggested for further study.

Appendix F: Raw Data Obtained from the Observation based on Twelve Hairdressers in Taiwan

A: Hair-washing with standing position
B: Hair-washing in the washbasin area
C: Hair-straightening
D: Hair-blow-drying

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
001	[00:00:16.02]	[00:01:03.55]	A1	48.0	002	[00:09:50.40]	[00:09:57.87]	A3	8.0
001	[00:01:11.10]	[00:01:15.76]	A3	5.0	002	[00:09:58.40]	[00:10:14.40]	A2	16.0
001	[00:01:16.80]	[00:01:21.60]	A2	5.0	002	[00:10:15.47]	[00:10:58.67]	A3	44.0
001	[00:01:22.40]	[00:01:24.40]	A3	2.0	004	[00:00:01.60]	[00:01:41.33]	A1	99.0
001	[00:01:24.51]	[00:01:29.86]	A2	5.0	004	[00:01:47.20]	[00:02:04.80]	A2	18.0
001	[00:01:38.48]	[00:01:56.92]	A4	19.0	004	[00:02:06.40]	[00:02:21.33]	A3	15.0
001	[00:02:00.30]	[00:02:20.54]	A1	21.0	004	[00:02:41.60]	[00:02:56.53]	A4	15.0
001	[00:02:24.02]	[00:02:37.53]	A2	14.0	004	[00:02:59.73]	[00:03:54.17]	A1	54.0
001	[00:02:42.39]	[00:03:02.86]	A3	21.0	004	[00:03:57.37]	[00:04:16.03]	A2	19.0
001	[00:03:04.26]	[00:03:15.99]	A2	12.0	004	[00:04:18.70]	[00:04:46.97]	A3	28.0
001	[00:03:18.01]	[00:03:20.85]	A3	3.0	004	[00:04:46.43]	[00:04:53.90]	A2	8.0
001	[00:03:21.98]	[00:03:25.08]	A2	3.0	004	[00:04:55.50]	[00:05:08.30]	A3	12.0
001	[00:03:26.22]	[00:03:34.91]	A3	9.0	004	[00:05:09.37]	[00:05:26.97]	A2	18.0
001	[00:03:35.92]	[00:03:50.26]	A2	14.0	004	[00:05:28.03]	[00:05:57.37]	A3	29.0
001	[00:03:51.08]	[00:04:23.13]	A3	32.0	004	[00:05:59.50]	[00:06:54.97]	A2	55.0
001	[00:04:23.99]	[00:04:29.34]	A2	5.0	004	[00:06:55.50]	[00:07:08.53]	A3	14.0
001	[00:04:32.03]	[00:04:45.33]	A3	13.0	004	[00:07:09.60]	[00:07:55.47]	A2	45.0
001	[00:04:46.24]	[00:05:10.23]	A2	24.0	004	[00:07:57.07]	[00:08:10.93]	A3	14.0
001	[00:05:11.30]	[00:05:14.83]	A3	4.0	004	[00:08:11.47]	[00:08:24.27]	A2	13.0
001	[00:05:15.90]	[00:05:35.84]	A2	20.0	004	[00:08:25.33]	[00:08:44.00]	A3	19.0
001	[00:05:36.82]	[00:05:39.47]	A3	2.0	004	[00:08:45.60]	[00:09:06.40]	A2	20.0
001	[00:05:40.36]	[00:05:43.18]	A2	3.0	004	[00:09:08.00]	[00:09:14.93]	A3	7.0
001	[00:05:43.94]	[00:05:52.98]	A3	9.0	004	[00:09:14.40]	[00:09:33.07]	A2	19.0
001	[00:05:53.87]	[00:06:15.23]	A2	21.0	004	[00:09:34.67]	[00:09:57.07]	A3	22.0
001	[00:06:16.39]	[00:06:18.87]	A3	3.0	004	[00:09:58.13]	[00:10:48.80]	A2	51.0
001	[00:06:19.88]	[00:07:01.08]	A2	41.0	008	[00:00:02.67]	[00:01:30.13]	A1	87.0
002	[00:00:02.67]	[00:01:50.93]	A1	108.0	008	[00:01:32.80]	[00:03:20.00]	A3	107.0
002	[00:01:52.53]	[00:02:35.73]	A3	43.0	008	[00:03:26.93]	[00:03:41.33]	A4	14.0
002	[00:02:36.80]	[00:02:40.53]	A2	4.0	008	[00:03:44.00]	[00:04:25.07]	A1	41.0
002	[00:02:41.60]	[00:03:12.00]	A3	30.0	008	[00:04:26.67]	[00:04:28.27]	A3	1.0
002	[00:03:12.53]	[00:03:16.27]	A2	3.0	008	[00:04:29.33]	[00:04:43.20]	A2	14.0
002	[00:03:17.33]	[00:03:20.00]	A3	3.0	008	[00:04:44.27]	[00:05:05.07]	A3	21.0
002	[00:03:21.07]	[00:03:30.67]	A2	10.0	008	[00:05:06.13]	[00:05:14.67]	A2	9.0
002	[00:03:31.73]	[00:03:54.67]	A3	23.0	008	[00:05:15.20]	[00:05:18.93]	A3	4.0
002	[00:03:55.20]	[00:03:58.93]	A2	4.0	008	[00:05:19.47]	[00:05:31.20]	A2	12.0
002	[00:04:00.00]	[00:04:02.67]	A3	3.0	008	[00:05:31.73]	[00:05:35.47]	A3	3.0
002	[00:04:04.80]	[00:04:25.07]	A4	20.0	008	[00:05:36.00]	[00:05:39.73]	A2	4.0
002	[00:04:26.13]	[00:05:17.87]	A1	52.0	008	[00:05:40.27]	[00:06:11.73]	A3	32.0
002	[00:05:18.93]	[00:05:24.80]	A2	6.0	008	[00:06:12.80]	[00:06:32.00]	A2	19.0
002	[00:05:25.87]	[00:05:53.60]	A3	28.0	008	[00:06:32.53]	[00:06:51.20]	A3	18.0
002	[00:05:54.13]	[00:05:58.40]	A2	4.0	008	[00:06:52.27]	[00:07:11.47]	A2	19.0
002	[00:05:58.93]	[00:06:03.20]	A3	4.0	008	[00:07:12.00]	[00:07:21.07]	A3	9.0
002	[00:06:03.73]	[00:06:27.73]	A2	24.0	008	[00:07:21.60]	[00:07:26.40]	A2	4.0
002	[00:06:28.80]	[00:07:12.00]	A3	43.0	008	[00:07:26.93]	[00:08:11.20]	A3	44.0
002	[00:07:12.53]	[00:07:24.80]	A2	12.0	008	[00:08:11.73]	[00:08:51.20]	A2	39.0
002	[00:07:25.87]	[00:08:20.27]	A3	54.0	008	[00:08:51.73]	[00:08:56.53]	A3	5.0
002	[00:08:21.87]	[00:08:35.20]	A2	13.0	008	[00:08:57.07]	[00:09:05.07]	A2	8.0
002	[00:08:35.73]	[00:08:55.47]	A3	19.0	008	[00:09:06.13]	[00:09:26.40]	A3	20.0
002	[00:08:56.00]	[00:09:28.53]	A2	33.0	008	[00:09:26.93]	[00:09:43.47]	A2	16.0
002	[00:09:31.20]	[00:09:36.53]	A3	6.0	008	[00:09:44.00]	[00:10:09.60]	A3	26.0
002	[00:09:37.07]	[00:09:49.33]	A2	12.0	008	[00:10:10.67]	[00:10:19.73]	A2	9.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
008	[00:10:20.80]	[00:10:31.47]	A3	10.0	009	[00:30:11.20]	[00:30:28.80]	A2	18.0
007	[00:00:02.67]	[00:01:26.40]	A1	83.0	010	[00:00:03.20]	[00:01:16.80]	A1	74.0
007	[00:01:27.47]	[00:01:34.93]	A2	8.0	010	[00:01:18.93]	[00:01:24.80]	A2	6.0
007	[00:01:37.07]	[00:02:52.80]	A3	76.0	010	[00:01:25.33]	[00:01:34.93]	A3	10.0
007	[00:02:56.00]	[00:03:12.00]	A4	16.0	010	[00:01:35.47]	[00:01:38.67]	A2	4.0
007	[00:03:13.60]	[00:04:01.60]	A1	48.0	010	[00:01:39.20]	[00:01:43.47]	A3	4.0
007	[00:04:02.67]	[00:04:34.67]	A3	32.0	010	[00:01:44.00]	[00:01:49.33]	A2	5.0
007	[00:04:35.73]	[00:04:40.00]	A2	4.0	010	[00:01:49.87]	[00:01:57.33]	A3	7.0
007	[00:04:41.07]	[00:05:06.13]	A3	25.0	010	[00:01:58.40]	[00:02:01.07]	A2	3.0
007	[00:05:06.67]	[00:05:12.00]	A2	5.0	010	[00:02:01.60]	[00:02:11.73]	A3	10.0
007	[00:05:13.07]	[00:05:28.00]	A3	15.0	010	[00:02:12.80]	[00:02:19.20]	A2	6.0
007	[00:05:29.07]	[00:05:42.93]	A2	14.0	010	[00:02:22.40]	[00:02:42.13]	A4	20.0
007	[00:05:44.00]	[00:05:53.60]	A3	10.0	010	[00:02:42.67]	[00:03:16.80]	A1	34.0
007	[00:05:54.13]	[00:06:06.93]	A2	13.0	010	[00:03:18.40]	[00:03:22.13]	A2	4.0
007	[00:06:08.53]	[00:06:25.07]	A2	16.0	010	[00:03:23.20]	[00:03:34.40]	A3	11.0
007	[00:06:25.60]	[00:06:40.00]	A3	14.0	010	[00:03:34.93]	[00:03:36.53]	A2	2.0
007	[00:06:40.53]	[00:07:15.20]	A3	34.0	010	[00:03:37.07]	[00:04:02.67]	A3	26.0
007	[00:07:15.73]	[00:07:46.67]	A2	31.0	010	[00:04:03.20]	[00:04:05.87]	A2	3.0
007	[00:07:47.73]	[00:08:00.53]	A3	13.0	010	[00:04:06.40]	[00:04:48.53]	A3	43.0
007	[00:08:01.60]	[00:08:29.87]	A2	28.0	010	[00:04:49.60]	[00:04:56.00]	A2	6.0
007	[00:08:30.40]	[00:08:37.33]	A3	7.0	010	[00:04:57.07]	[00:05:21.60]	A3	25.0
007	[00:08:38.40]	[00:09:02.40]	A2	24.0	010	[00:05:22.13]	[00:05:53.07]	A2	31.0
009	[00:18:16.00]	[00:19:06.67]	A1	51.0	010	[00:05:54.13]	[00:06:29.33]	A3	35.0
009	[00:19:07.73]	[00:19:10.40]	A2	2.0	012	[00:48:47.47]	[00:50:25.07]	A1	98.0
009	[00:19:11.47]	[00:20:05.33]	A3	54.0	012	[00:50:29.87]	[00:51:25.87]	A3	56.0
009	[00:20:05.87]	[00:20:12.80]	A2	7.0	012	[00:51:26.40]	[00:51:35.47]	A2	9.0
009	[00:20:24.00]	[00:20:34.13]	A4	10.0	012	[00:51:38.67]	[00:51:47.73]	A4	9.0
009	[00:20:35.20]	[00:20:52.80]	A1	18.0	012	[00:51:48.27]	[00:52:24.00]	A1	36.0
009	[00:20:53.33]	[00:20:56.53]	A2	4.0	012	[00:52:25.07]	[00:53:31.20]	A3	66.0
009	[00:20:57.07]	[00:21:58.93]	A3	62.0	012	[00:53:32.27]	[00:54:03.73]	A2	32.0
009	[00:22:01.60]	[00:22:00.00]	A2	-2.0	012	[00:54:04.27]	[00:54:08.00]	A3	4.0
009	[00:22:01.07]	[00:22:17.60]	A2	17.0	012	[00:54:09.07]	[00:54:22.40]	A2	13.0
009	[00:22:18.67]	[00:22:24.53]	A1	6.0	012	[00:54:22.93]	[00:54:41.07]	A3	18.0
009	[00:22:26.67]	[00:22:28.27]	A2	1.0	012	[00:54:41.60]	[00:54:46.40]	A2	4.0
009	[00:22:29.33]	[00:22:40.53]	A2	12.0	012	[00:54:46.93]	[00:54:50.67]	A3	4.0
009	[00:22:41.60]	[00:22:44.27]	A3	2.0	012	[00:54:51.20]	[00:55:02.93]	A2	12.0
009	[00:22:44.80]	[00:23:15.20]	A2	30.0	012	[00:55:04.00]	[00:55:07.20]	A3	3.0
009	[00:23:16.27]	[00:23:36.00]	A3	20.0	012	[00:55:08.27]	[00:55:20.00]	A2	12.0
009	[00:23:36.53]	[00:23:48.80]	A2	12.0	012	[00:55:20.53]	[00:55:27.47]	A3	6.0
009	[00:23:49.33]	[00:23:52.53]	A3	4.0	012	[00:55:28.53]	[00:55:32.27]	A2	3.0
009	[00:23:53.07]	[00:24:35.73]	A2	43.0	012	[00:55:32.80]	[00:55:42.93]	A3	10.0
009	[00:24:36.27]	[00:24:39.47]	A3	3.0	012	[00:55:44.00]	[00:56:04.27]	A2	20.0
009	[00:24:40.53]	[00:24:53.87]	A2	13.0	012	[00:56:05.33]	[00:56:46.93]	A3	42.0
009	[00:24:54.40]	[00:25:02.93]	A3	9.0	012	[00:56:48.00]	[00:57:08.80]	A2	21.0
009	[00:25:03.47]	[00:25:09.87]	A2	7.0	012	[00:57:12.00]	[00:57:19.47]	A4	7.0
009	[00:25:10.40]	[00:25:18.40]	A3	8.0	012	[00:57:20.00]	[00:58:14.40]	A1	54.0
009	[00:25:19.47]	[00:25:32.80]	A2	14.0	012	[00:58:16.00]	[00:59:12.00]	A3	56.0
009	[00:25:33.33]	[00:25:46.67]	A3	14.0	012	[00:59:12.00]	[00:59:34.93]	A2	23.0
009	[00:25:47.20]	[00:26:21.33]	A2	34.0	012	[00:59:35.47]	[00:59:39.20]	A3	4.0
009	[00:26:21.87]	[00:26:38.40]	A3	16.0	012	[00:59:40.27]	[00:59:45.60]	A2	6.0
009	[00:26:38.93]	[00:26:40.00]	A3	1.0	012	[00:59:46.13]	[00:59:53.07]	A3	7.0
009	[00:26:41.60]	[00:27:53.60]	A3	72.0	001	[00:00:37.53]	[00:01:37.64]	B2	60.0
009	[00:27:54.67]	[00:28:09.60]	A2	15.0	001	[00:01:39.87]	[00:01:47.49]	B5	7.0
009	[00:28:10.13]	[00:28:31.47]	A3	21.0	001	[00:01:49.11]	[00:01:52.50]	B5	3.0
009	[00:28:32.53]	[00:29:05.07]	A2	32.0	001	[00:01:55.06]	[00:02:01.61]	B5	7.0
009	[00:29:06.13]	[00:29:13.60]	A2	8.0	001	[00:02:07.93]	[00:02:38.07]	B2	30.0
009	[00:29:14.13]	[00:29:27.47]	A3	13.0	001	[00:02:45.72]	[00:02:53.18]	B5	7.0
009	[00:29:28.00]	[00:29:38.67]	A2	11.0	001	[00:02:55.02]	[00:02:59.61]	B5	5.0
009	[00:29:39.73]	[00:29:44.53]	A3	5.0	001	[00:03:01.62]	[00:03:09.30]	B5	7.0
009	[00:29:45.07]	[00:30:03.73]	A2	19.0	001	[00:03:19.89]	[00:03:32.40]	B2	12.0
009	[00:30:04.80]	[00:30:10.13]	A3	5.0	001	[00:03:33.36]	[00:03:37.21]	B5	4.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
001	[00:03:38.15]	[00:03:43.41]	B5	5.0	001	[00:26:04.80]	[00:26:13.33]	B7	8.0
001	[00:03:47.01]	[00:03:53.38]	B5	6.0	001	[00:26:21.87]	[00:26:32.00]	B7	10.0
001	[00:03:57.47]	[00:04:02.40]	B5	5.0	001	[00:26:36.27]	[00:26:46.93]	B7	11.0
001	[00:04:11.21]	[00:04:51.38]	B2	40.0	001	[00:27:03.47]	[00:27:13.07]	B7	10.0
001	[00:04:53.02]	[00:05:03.48]	B5	10.0	001	[00:27:18.40]	[00:27:24.27]	B7	6.0
001	[00:05:08.96]	[00:05:13.48]	B5	4.0	001	[00:27:27.47]	[00:27:32.80]	B7	6.0
001	[00:05:18.90]	[00:05:25.35]	B5	6.0	001	[00:27:46.13]	[00:27:57.33]	B7	11.0
001	[00:05:34.52]	[00:05:43.53]	B5	9.0	001	[00:28:00.53]	[00:28:05.87]	B7	5.0
001	[00:06:01.23]	[00:06:07.71]	B5	7.0	001	[00:28:21.33]	[00:28:27.20]	B7	6.0
001	[00:06:16.58]	[00:06:21.54]	B5	5.0	001	[00:28:35.20]	[00:28:44.27]	B7	9.0
001	[00:06:38.65]	[00:06:47.20]	B5	8.0	001	[00:28:54.40]	[00:29:02.93]	B7	9.0
001	[00:07:07.89]	[00:07:13.21]	B5	5.0	001	[00:29:07.73]	[00:29:11.47]	B7	3.0
001	[00:07:19.25]	[00:07:22.47]	B5	3.0	001	[00:29:20.53]	[00:29:25.33]	B7	4.0
001	[00:07:24.55]	[00:07:30.01]	B5	5.0	001	[00:29:35.47]	[00:29:41.87]	B7	7.0
001	[00:07:47.50]	[00:08:32.97]	B2	45.0	001	[00:30:06.40]	[00:30:13.33]	B7	7.0
001	[00:08:38.80]	[00:08:44.56]	B5	6.0	001	[00:30:21.33]	[00:30:25.60]	B7	5.0
001	[00:08:47.79]	[00:08:54.59]	B5	7.0	002	[00:00:12.27]	[00:00:37.33]	B2	25.0
001	[00:09:00.34]	[00:09:05.39]	B5	5.0	002	[00:00:41.60]	[00:00:51.20]	B7	9.0
001	[00:09:11.31]	[00:09:17.32]	B5	6.0	002	[00:00:54.40]	[00:00:57.07]	B7	3.0
001	[00:09:23.40]	[00:09:27.71]	B5	5.0	002	[00:01:02.40]	[00:01:09.33]	B7	7.0
001	[00:09:35.53]	[00:09:42.20]	B5	6.0	002	[00:01:15.20]	[00:01:19.47]	B7	4.0
001	[00:10:01.52]	[00:10:08.56]	B5	7.0	002	[00:01:22.67]	[00:01:30.13]	B7	7.0
001	[00:10:18.06]	[00:10:23.39]	B5	5.0	002	[00:01:33.33]	[00:01:38.67]	B7	6.0
001	[00:10:38.73]	[00:11:32.34]	B2	53.0	002	[00:01:41.87]	[00:01:44.53]	B7	3.0
001	[00:11:53.22]	[00:11:58.98]	B5	6.0	002	[00:01:45.60]	[00:01:49.87]	B6	4.0
001	[00:12:02.80]	[00:12:08.47]	B5	5.0	002	[00:01:52.00]	[00:01:57.33]	B6	5.0
001	[00:12:24.80]	[00:12:28.69]	B5	4.0	002	[00:01:58.40]	[00:02:03.73]	B6	6.0
001	[00:12:31.89]	[00:12:42.44]	B5	10.0	002	[00:02:06.93]	[00:02:10.13]	B6	3.0
001	[00:12:48.89]	[00:12:53.54]	B5	5.0	002	[00:02:12.80]	[00:02:22.40]	B7	9.0
001	[00:13:55.19]	[00:14:11.37]	B2	16.0	002	[00:02:25.07]	[00:02:32.53]	B7	8.0
001	[00:14:24.27]	[00:14:33.50]	B5	9.0	002	[00:02:42.67]	[00:02:45.87]	B6	3.0
001	[00:14:37.50]	[00:14:45.44]	B5	8.0	002	[00:02:54.93]	[00:03:01.33]	B7	6.0
001	[00:15:28.66]	[00:15:33.26]	B6	4.0	002	[00:03:03.47]	[00:03:08.27]	B7	5.0
001	[00:15:36.68]	[00:15:43.40]	B6	6.0	002	[00:03:18.40]	[00:03:24.80]	B7	7.0
001	[00:16:05.96]	[00:16:08.90]	B6	3.0	002	[00:03:25.87]	[00:03:29.07]	B7	3.0
001	[00:17:25.87]	[00:17:55.20]	B2	29.0	002	[00:03:32.80]	[00:03:37.60]	B7	5.0
001	[00:18:05.87]	[00:18:27.20]	B4	21.0	002	[00:03:37.60]	[00:03:39.73]	B7	2.0
001	[00:18:30.40]	[00:18:57.60]	B4	28.0	002	[00:03:41.87]	[00:03:46.67]	B7	5.0
001	[00:19:02.93]	[00:19:21.60]	B4	19.0	002	[00:03:47.73]	[00:03:51.47]	B7	3.0
001	[00:19:41.87]	[00:19:48.80]	B4	7.0	002	[00:03:52.00]	[00:03:56.80]	B7	5.0
001	[00:19:58.40]	[00:20:03.20]	B4	5.0	002	[00:03:59.47]	[00:04:03.73]	B7	5.0
001	[00:20:13.87]	[00:20:24.00]	B4	10.0	002	[00:04:04.80]	[00:04:09.07]	B7	4.0
001	[00:20:26.67]	[00:20:32.00]	B4	5.0	002	[00:04:09.07]	[00:04:12.27]	B7	3.0
001	[00:20:46.40]	[00:20:52.80]	B4	7.0	002	[00:04:24.53]	[00:04:28.27]	B7	3.0
001	[00:20:54.93]	[00:20:59.20]	B4	4.0	002	[00:04:31.47]	[00:04:44.80]	B2	14.0
001	[00:21:15.20]	[00:21:23.73]	B4	9.0	002	[00:04:51.20]	[00:04:59.73]	B7	9.0
001	[00:21:33.87]	[00:21:42.93]	B4	9.0	002	[00:05:00.27]	[00:05:16.80]	B7	17.0
001	[00:22:03.20]	[00:22:08.00]	B4	5.0	002	[00:05:20.53]	[00:05:28.00]	B7	7.0
001	[00:22:17.07]	[00:22:24.53]	B7	8.0	002	[00:05:30.67]	[00:05:35.47]	B7	4.0
001	[00:22:38.40]	[00:22:44.80]	B7	7.0	002	[00:05:37.07]	[00:05:40.80]	B7	4.0
001	[00:22:57.07]	[00:23:04.53]	B7	8.0	002	[00:05:45.60]	[00:05:51.47]	B7	5.0
001	[00:23:12.00]	[00:23:17.33]	B7	5.0	002	[00:05:57.87]	[00:06:02.67]	B7	5.0
001	[00:23:26.40]	[00:23:34.40]	B7	8.0	002	[00:06:05.87]	[00:06:12.27]	B7	6.0
001	[00:23:39.73]	[00:23:45.07]	B7	5.0	002	[00:06:16.53]	[00:06:22.93]	B7	6.0
001	[00:23:49.33]	[00:23:55.20]	B7	6.0	002	[00:06:27.20]	[00:06:34.13]	B7	7.0
001	[00:24:06.93]	[00:24:12.80]	B7	6.0	002	[00:06:40.53]	[00:06:47.47]	B7	6.0
001	[00:24:24.53]	[00:24:27.73]	B7	3.0	002	[00:06:50.67]	[00:06:57.60]	B7	7.0
001	[00:24:48.53]	[00:24:56.53]	B7	8.0	002	[00:07:01.87]	[00:07:10.40]	B7	8.0
001	[00:25:04.53]	[00:25:18.93]	B7	14.0	002	[00:07:12.00]	[00:07:17.87]	B6	6.0
001	[00:25:24.80]	[00:25:35.47]	B7	10.0	002	[00:07:19.47]	[00:07:22.13]	B6	3.0
001	[00:25:38.67]	[00:25:42.93]	B7	4.0	002	[00:07:25.33]	[00:07:42.40]	B2	17.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
002	[00:07:52.00]	[00:07:57.33]	B7	5.0	002	[00:18:06.93]	[00:18:11.73]	B7	5.0
002	[00:08:01.60]	[00:08:08.53]	B7	7.0	002	[00:18:17.60]	[00:18:20.80]	B7	3.0
002	[00:08:11.73]	[00:08:17.07]	B7	5.0	002	[00:18:26.67]	[00:18:33.07]	B6	6.0
002	[00:08:23.47]	[00:08:27.73]	B7	5.0	002	[00:18:36.27]	[00:18:42.67]	B6	7.0
002	[00:08:30.40]	[00:08:36.80]	B7	7.0	002	[00:18:46.40]	[00:18:49.60]	B6	4.0
002	[00:08:39.47]	[00:08:44.80]	B7	6.0	002	[00:18:57.60]	[00:19:01.87]	B6	4.0
002	[00:08:47.47]	[00:08:52.27]	B7	5.0	002	[00:19:15.73]	[00:19:18.93]	B4	3.0
002	[00:09:00.27]	[00:09:04.53]	B6	5.0	002	[00:19:21.60]	[00:19:26.40]	B4	4.0
002	[00:09:07.73]	[00:09:10.93]	B6	3.0	002	[00:19:49.87]	[00:19:55.20]	B6	5.0
002	[00:09:25.33]	[00:09:30.67]	B7	6.0	002	[00:19:59.47]	[00:20:04.80]	B6	6.0
002	[00:09:33.33]	[00:09:38.67]	B7	6.0	002	[00:20:06.93]	[00:20:10.67]	B6	4.0
002	[00:09:42.40]	[00:09:48.80]	B7	7.0	002	[00:20:16.53]	[00:20:22.40]	B6	5.0
002	[00:09:51.47]	[00:09:55.73]	B7	5.0	002	[00:20:22.93]	[00:20:26.67]	B6	4.0
002	[00:09:59.47]	[00:10:04.27]	B7	5.0	002	[00:20:27.73]	[00:20:32.00]	B6	4.0
002	[00:10:07.47]	[00:10:12.27]	B7	5.0	002	[00:20:37.87]	[00:20:41.60]	B6	4.0
002	[00:10:16.00]	[00:10:20.27]	B7	4.0	002	[00:20:44.27]	[00:20:48.00]	B6	4.0
002	[00:10:22.40]	[00:10:26.67]	B7	5.0	002	[00:20:53.87]	[00:20:58.13]	B6	4.0
002	[00:10:35.20]	[00:10:45.33]	B2	10.0	002	[00:21:00.27]	[00:21:04.00]	B6	4.0
002	[00:10:48.00]	[00:10:53.33]	B6	5.0	002	[00:21:14.13]	[00:21:19.47]	B7	5.0
002	[00:10:56.00]	[00:11:03.47]	B7	7.0	002	[00:21:21.60]	[00:21:23.20]	B7	1.0
002	[00:11:05.60]	[00:11:12.53]	B7	7.0	002	[00:21:30.13]	[00:21:33.87]	B7	4.0
002	[00:11:16.80]	[00:11:22.13]	B7	5.0	002	[00:21:34.93]	[00:21:38.67]	B7	4.0
002	[00:11:25.33]	[00:11:34.40]	B7	9.0	002	[00:21:42.40]	[00:21:45.07]	B6	3.0
002	[00:11:43.47]	[00:11:48.27]	B7	5.0	002	[00:21:50.93]	[00:21:55.73]	B7	5.0
002	[00:11:52.00]	[00:11:55.73]	B7	4.0	002	[00:21:57.33]	[00:22:00.00]	B7	3.0
002	[00:12:00.53]	[00:12:06.40]	B2	5.0	002	[00:22:03.73]	[00:22:06.93]	B7	3.0
002	[00:12:16.53]	[00:12:20.80]	B6	4.0	002	[00:22:09.07]	[00:22:11.20]	B6	2.0
002	[00:12:22.93]	[00:12:25.07]	B6	2.0	002	[00:22:18.67]	[00:22:21.87]	B7	3.0
002	[00:12:27.73]	[00:12:34.67]	B6	7.0	002	[00:22:23.47]	[00:22:27.20]	B7	4.0
002	[00:12:40.00]	[00:12:51.20]	B2	11.0	002	[00:22:29.87]	[00:22:32.53]	B6	3.0
002	[00:12:51.73]	[00:12:56.53]	B6	5.0	002	[00:22:37.87]	[00:22:40.53]	B6	3.0
002	[00:12:58.13]	[00:13:01.87]	B6	4.0	002	[00:22:49.07]	[00:22:56.53]	B6	8.0
002	[00:13:12.53]	[00:13:17.33]	B6	4.0	002	[00:23:15.20]	[00:23:18.40]	B6	3.0
002	[00:13:18.40]	[00:13:21.60]	B6	4.0	002	[00:23:21.07]	[00:23:24.80]	B7	4.0
002	[00:13:28.00]	[00:13:30.13]	B6	2.0	002	[00:23:26.40]	[00:23:32.27]	B7	6.0
002	[00:13:39.20]	[00:13:43.47]	B6	4.0	002	[00:23:47.20]	[00:23:50.93]	B6	4.0
002	[00:13:54.13]	[00:13:57.87]	B7	4.0	002	[00:23:53.07]	[00:23:56.27]	B6	3.0
002	[00:14:04.80]	[00:14:09.07]	B7	4.0	002	[00:24:16.53]	[00:24:20.27]	B6	3.0
002	[00:14:10.67]	[00:14:16.00]	B7	5.0	002	[00:24:21.33]	[00:24:24.53]	B6	4.0
002	[00:14:19.73]	[00:14:25.07]	B7	5.0	002	[00:24:26.67]	[00:24:29.33]	B6	2.0
002	[00:14:27.73]	[00:14:32.53]	B7	5.0	002	[00:24:32.00]	[00:24:34.13]	B6	2.0
002	[00:14:34.67]	[00:14:39.47]	B7	4.0	002	[00:24:41.10]	[00:24:44.83]	B6	4.0
002	[00:14:43.20]	[00:14:47.47]	B7	4.0	002	[00:24:48.03]	[00:24:51.23]	B6	3.0
002	[00:14:49.60]	[00:15:00.27]	B2	10.0	002	[00:24:57.63]	[00:25:00.30]	B6	2.0
002	[00:15:01.87]	[00:15:08.27]	B7	6.0	002	[00:25:05.10]	[00:25:07.77]	B6	3.0
002	[00:15:14.67]	[00:15:20.53]	B2	6.0	002	[00:25:09.90]	[00:25:11.50]	B6	2.0
002	[00:15:21.60]	[00:15:26.40]	B6	4.0	002	[00:25:33.90]	[00:29:01.97]	B5	208.0
002	[00:15:28.53]	[00:15:33.33]	B7	4.0	002	[00:29:07.30]	[00:29:11.57]	B6	5.0
002	[00:15:36.53]	[00:15:39.73]	B7	3.0	002	[00:29:14.77]	[00:29:20.10]	B6	5.0
002	[00:15:43.47]	[00:15:46.67]	B7	4.0	002	[00:29:22.77]	[00:29:27.03]	B7	4.0
002	[00:15:52.00]	[00:15:54.13]	B7	2.0	002	[00:29:34.50]	[00:30:35.30]	B5	60.0
002	[00:16:02.67]	[00:16:06.93]	B7	4.0	004	[00:11:02.13]	[00:12:05.97]	B2	64.0
002	[00:16:12.27]	[00:16:16.00]	B7	4.0	004	[00:12:11.30]	[00:12:20.37]	B1	9.0
002	[00:17:07.20]	[00:17:10.40]	B6	3.0	004	[00:12:23.03]	[00:12:31.57]	B1	9.0
002	[00:17:13.60]	[00:17:17.33]	B6	3.0	004	[00:12:42.23]	[00:12:50.77]	B1	9.0
002	[00:17:18.93]	[00:17:23.73]	B6	5.0	004	[00:12:59.83]	[00:13:09.97]	B1	10.0
002	[00:17:25.87]	[00:17:30.67]	B6	5.0	004	[00:13:15.30]	[00:13:24.90]	B1	10.0
002	[00:17:33.87]	[00:17:38.13]	B7	4.0	004	[00:13:33.97]	[00:13:55.83]	B2	22.0
002	[00:17:41.87]	[00:17:45.60]	B7	4.0	004	[00:14:02.23]	[00:14:11.30]	B1	9.0
002	[00:17:48.80]	[00:17:53.60]	B7	5.0	004	[00:14:14.50]	[00:14:24.63]	B1	10.0
002	[00:17:58.40]	[00:18:02.13]	B7	4.0	004	[00:14:35.30]	[00:14:44.90]	B1	10.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
004	[00:15:03.03]	[00:15:22.77]	B1	20.0	007	[00:06:38.93]	[00:06:42.13]	B4	3.0
004	[00:15:28.63]	[00:15:39.83]	B1	11.0	007	[00:07:17.33]	[00:07:33.87]	B3	17.0
004	[00:16:11.30]	[00:16:22.50]	B1	11.0	007	[00:07:36.00]	[00:07:42.93]	B3	7.0
004	[00:16:55.57]	[00:17:01.97]	B3	6.0	007	[00:07:45.07]	[00:07:55.20]	B3	10.0
004	[00:17:04.10]	[00:17:16.90]	B3	13.0	007	[00:08:11.20]	[00:08:17.07]	B3	6.0
004	[00:17:30.77]	[00:17:39.30]	B3	8.0	007	[00:08:19.73]	[00:08:24.53]	B3	5.0
004	[00:17:45.70]	[00:17:52.10]	B3	6.0	007	[00:08:28.80]	[00:08:31.47]	B4	2.0
004	[00:18:13.97]	[00:18:21.97]	B4	8.0	007	[00:08:33.60]	[00:08:35.73]	B4	2.0
004	[00:18:26.77]	[00:18:31.57]	B4	5.0	007	[00:08:37.33]	[00:08:39.47]	B4	2.0
004	[00:18:34.77]	[00:18:41.17]	B4	6.0	007	[00:08:49.07]	[00:09:01.87]	B3	13.0
004	[00:18:43.83]	[00:18:51.83]	B4	8.0	007	[00:09:04.00]	[00:09:10.40]	B3	6.0
004	[00:18:54.50]	[00:19:00.37]	B4	6.0	007	[00:09:21.60]	[00:09:37.60]	B3	16.0
004	[00:19:03.57]	[00:19:12.10]	B4	8.0	007	[00:09:40.80]	[00:09:52.00]	B3	11.0
004	[00:19:16.90]	[00:19:24.37]	B4	7.0	007	[00:09:54.13]	[00:10:00.53]	B3	7.0
004	[00:19:32.37]	[00:19:39.30]	B4	7.0	007	[00:10:16.53]	[00:10:22.40]	B3	5.0
004	[00:19:41.97]	[00:19:44.63]	B4	3.0	007	[00:10:24.53]	[00:10:27.20]	B4	2.0
004	[00:19:47.30]	[00:19:53.70]	B4	7.0	007	[00:10:32.53]	[00:10:36.80]	B7	4.0
004	[00:19:56.90]	[00:20:05.43]	B4	8.0	007	[00:10:37.87]	[00:10:43.20]	B7	5.0
004	[00:20:24.10]	[00:20:28.90]	B3	5.0	007	[00:10:44.27]	[00:10:49.07]	B7	5.0
007	[00:00:20.80]	[00:01:02.93]	B4	42.0	007	[00:10:57.07]	[00:11:08.80]	B4	12.0
007	[00:01:06.13]	[00:01:15.20]	B4	9.0	007	[00:11:10.93]	[00:11:25.33]	B4	14.0
007	[00:01:26.40]	[00:01:58.40]	B4	32.0	007	[00:11:30.67]	[00:11:33.87]	B4	3.0
007	[00:02:11.20]	[00:02:34.13]	B6	23.0	007	[00:11:36.53]	[00:11:47.73]	B4	11.0
007	[00:02:39.47]	[00:02:53.87]	B6	15.0	007	[00:11:48.80]	[00:11:51.47]	B7	2.0
007	[00:03:02.40]	[00:03:18.40]	B6	16.0	007	[00:11:53.07]	[00:11:55.20]	B7	2.0
007	[00:03:22.67]	[00:03:36.00]	B6	13.0	007	[00:11:57.33]	[00:11:58.93]	B7	2.0
007	[00:03:44.00]	[00:03:46.67]	B3	3.0	007	[00:12:00.00]	[00:12:03.20]	B7	3.0
007	[00:03:48.27]	[00:03:51.47]	B3	3.0	007	[00:12:05.33]	[00:12:10.13]	B7	5.0
007	[00:03:53.60]	[00:03:57.33]	B3	3.0	007	[00:12:11.20]	[00:12:15.47]	B7	4.0
007	[00:03:58.93]	[00:04:02.67]	B3	4.0	007	[00:12:17.60]	[00:12:20.27]	B7	2.0
007	[00:04:04.27]	[00:04:08.00]	B3	4.0	007	[00:12:21.33]	[00:12:26.13]	B7	5.0
007	[00:04:09.60]	[00:04:12.80]	B3	3.0	007	[00:12:27.73]	[00:12:29.87]	B7	2.0
007	[00:04:14.40]	[00:04:16.53]	B3	3.0	007	[00:12:32.53]	[00:12:34.67]	B7	2.0
007	[00:04:19.73]	[00:04:22.40]	B3	2.0	007	[00:12:36.27]	[00:12:39.47]	B7	3.0
007	[00:04:23.47]	[00:04:27.20]	B3	4.0	007	[00:12:41.60]	[00:12:44.27]	B7	2.0
007	[00:04:28.80]	[00:04:31.47]	B3	2.0	007	[00:12:47.47]	[00:12:50.13]	B7	3.0
007	[00:04:33.07]	[00:04:36.27]	B3	3.0	007	[00:12:52.27]	[00:12:55.47]	B7	3.0
007	[00:04:38.40]	[00:04:41.60]	B3	4.0	007	[00:12:57.07]	[00:13:00.27]	B7	3.0
007	[00:04:44.27]	[00:04:46.40]	B3	2.0	007	[00:13:01.87]	[00:13:05.60]	B7	4.0
007	[00:04:50.13]	[00:04:52.27]	B3	2.0	007	[00:13:13.60]	[00:13:15.73]	B3	2.0
007	[00:04:56.00]	[00:04:59.20]	B3	3.0	007	[00:13:18.93]	[00:13:24.27]	B3	5.0
007	[00:05:01.33]	[00:05:04.00]	B3	3.0	007	[00:13:26.40]	[00:13:31.20]	B7	5.0
007	[00:05:06.67]	[00:05:08.27]	B3	1.0	007	[00:13:33.87]	[00:13:35.47]	B3	1.0
007	[00:05:10.93]	[00:05:12.00]	B3	1.0	007	[00:13:41.33]	[00:13:50.40]	B4	9.0
007	[00:05:18.40]	[00:05:20.53]	B3	3.0	007	[00:13:53.07]	[00:13:55.73]	B4	3.0
007	[00:05:22.67]	[00:05:25.33]	B3	2.0	007	[00:13:59.47]	[00:14:08.53]	B3	10.0
007	[00:05:27.47]	[00:05:30.13]	B3	3.0	007	[00:14:09.60]	[00:14:13.87]	B7	4.0
007	[00:05:32.27]	[00:05:34.93]	B3	3.0	007	[00:14:16.00]	[00:14:18.13]	B7	2.0
007	[00:05:37.60]	[00:05:38.67]	B3	1.0	007	[00:14:20.27]	[00:14:23.47]	B7	3.0
007	[00:05:40.80]	[00:05:45.07]	B3	4.0	007	[00:14:34.67]	[00:14:39.47]	B7	4.0
007	[00:05:46.67]	[00:05:49.33]	B3	2.0	007	[00:14:41.07]	[00:14:43.73]	B7	3.0
007	[00:05:50.93]	[00:05:53.07]	B3	2.0	007	[00:14:46.40]	[00:14:49.07]	B7	3.0
007	[00:05:55.20]	[00:05:58.40]	B4	3.0	007	[00:15:30.13]	[00:15:34.40]	B7	4.0
007	[00:05:59.47]	[00:06:02.13]	B4	3.0	007	[00:15:36.53]	[00:15:40.80]	B7	4.0
007	[00:06:03.73]	[00:06:06.93]	B4	3.0	007	[00:15:43.47]	[00:15:46.13]	B7	3.0
007	[00:06:08.00]	[00:06:10.13]	B4	2.0	007	[00:16:28.80]	[00:17:25.87]	B4	57.0
007	[00:06:11.20]	[00:06:14.40]	B3	3.0	007	[00:17:28.00]	[00:17:48.80]	B7	21.0
007	[00:06:16.00]	[00:06:18.67]	B3	3.0	007	[00:17:50.93]	[00:17:55.73]	B4	5.0
007	[00:06:20.27]	[00:06:24.00]	B3	4.0	007	[00:17:56.80]	[00:18:11.73]	B3	15.0
007	[00:06:25.60]	[00:06:28.80]	B3	3.0	007	[00:18:13.33]	[00:18:19.73]	B4	7.0
007	[00:06:34.67]	[00:06:37.87]	B4	3.0	008	[00:20:35.73]	[00:21:04.00]	B2	28.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
008	[00:21:06.67]	[00:21:18.40]	B3	11.0	010	[00:19:02.40]	[00:19:05.60]	B4	4.0
008	[00:21:20.53]	[00:21:37.60]	B3	17.0	010	[00:19:07.20]	[00:19:10.93]	B4	4.0
008	[00:21:38.67]	[00:21:46.13]	B3	7.0	010	[00:19:13.60]	[00:19:18.93]	B4	5.0
008	[00:21:57.33]	[00:22:06.40]	B7	9.0	010	[00:19:21.07]	[00:19:23.73]	B4	3.0
008	[00:22:13.33]	[00:22:27.20]	B7	14.0	010	[00:19:26.93]	[00:19:31.20]	B4	4.0
008	[00:22:30.93]	[00:22:42.13]	B7	11.0	010	[00:19:36.00]	[00:19:39.73]	B4	4.0
008	[00:22:48.53]	[00:22:59.20]	B7	10.0	010	[00:19:41.87]	[00:19:44.00]	B4	2.0
008	[00:23:01.33]	[00:23:11.47]	B6	10.0	010	[00:19:46.13]	[00:19:49.33]	B4	3.0
008	[00:23:17.87]	[00:23:41.87]	B2	24.0	010	[00:19:58.40]	[00:20:06.93]	B4	9.0
008	[00:23:51.47]	[00:24:05.33]	B7	14.0	010	[00:20:09.07]	[00:20:13.87]	B4	5.0
008	[00:24:19.73]	[00:24:35.73]	B7	16.0	010	[00:20:16.00]	[00:20:19.73]	B4	4.0
008	[00:24:49.07]	[00:25:07.20]	B7	18.0	010	[00:20:22.40]	[00:20:25.60]	B4	4.0
008	[00:25:20.53]	[00:25:32.27]	B7	11.0	010	[00:20:29.33]	[00:20:32.53]	B4	4.0
008	[00:25:53.07]	[00:26:08.00]	B7	15.0	010	[00:20:34.67]	[00:20:37.33]	B4	2.0
008	[00:26:11.20]	[00:26:19.20]	B7	8.0	010	[00:20:59.20]	[00:21:00.80]	B4	2.0
008	[00:26:33.60]	[00:26:42.67]	B7	9.0	010	[00:21:02.40]	[00:21:04.00]	B4	2.0
008	[00:26:51.20]	[00:27:04.53]	B7	14.0	010	[00:21:06.67]	[00:21:09.33]	B4	2.0
008	[00:27:13.07]	[00:27:24.80]	B7	12.0	010	[00:21:12.00]	[00:21:17.33]	B4	5.0
008	[00:27:36.00]	[00:27:47.73]	B7	12.0	010	[00:21:20.53]	[00:21:22.13]	B4	1.0
008	[00:27:52.53]	[00:28:02.13]	B7	9.0	010	[00:21:25.87]	[00:21:28.53]	B4	3.0
008	[00:28:14.40]	[00:28:22.40]	B7	8.0	010	[00:21:31.73]	[00:21:33.87]	B4	2.0
008	[00:28:53.87]	[00:29:04.53]	B4	11.0	010	[00:21:36.53]	[00:21:39.20]	B4	2.0
008	[00:29:08.80]	[00:29:15.20]	B4	6.0	010	[00:21:42.93]	[00:21:44.53]	B4	2.0
008	[00:29:30.13]	[00:29:42.93]	B4	13.0	010	[00:21:58.40]	[00:22:01.60]	B4	4.0
008	[00:30:00.00]	[00:30:12.80]	B4	13.0	010	[00:22:04.80]	[00:22:06.93]	B4	2.0
008	[00:30:16.53]	[00:30:24.53]	B4	8.0	010	[00:22:10.13]	[00:22:12.27]	B4	2.0
008	[00:30:36.27]	[00:30:47.47]	B4	11.0	010	[00:22:16.00]	[00:22:18.13]	B4	2.0
008	[00:31:04.53]	[00:31:21.07]	B4	16.0	010	[00:22:22.93]	[00:22:24.53]	B4	2.0
008	[00:31:34.40]	[00:31:50.93]	B4	17.0	010	[00:22:26.67]	[00:22:28.80]	B4	2.0
008	[00:31:58.93]	[00:32:10.13]	B4	11.0	010	[00:22:32.00]	[00:22:33.60]	B4	2.0
008	[00:32:13.33]	[00:32:16.53]	B4	4.0	010	[00:22:39.47]	[00:22:43.73]	B4	5.0
008	[00:32:33.07]	[00:32:43.20]	B4	10.0	010	[00:22:45.87]	[00:22:48.00]	B4	2.0
010	[00:14:43.73]	[00:14:55.47]	B1	11.0	010	[00:22:53.87]	[00:22:55.47]	B4	1.0
010	[00:14:57.07]	[00:15:03.47]	B1	6.0	010	[00:23:02.93]	[00:23:06.67]	B4	4.0
010	[00:15:04.53]	[00:15:09.87]	B1	5.0	010	[00:23:08.27]	[00:23:11.47]	B4	3.0
010	[00:15:12.00]	[00:15:15.73]	B1	4.0	010	[00:23:13.07]	[00:23:14.67]	B4	2.0
010	[00:15:18.93]	[00:15:22.13]	B1	3.0	010	[00:23:16.80]	[00:23:19.47]	B4	2.0
010	[00:15:23.20]	[00:15:27.47]	B1	4.0	010	[00:23:21.07]	[00:23:23.20]	B4	2.0
010	[00:15:30.67]	[00:15:37.07]	B1	6.0	010	[00:23:24.27]	[00:23:26.93]	B4	3.0
010	[00:15:41.33]	[00:15:46.13]	B1	5.0	010	[00:23:28.53]	[00:23:30.13]	B4	1.0
010	[00:15:48.80]	[00:15:53.07]	B1	4.0	010	[00:23:32.27]	[00:23:33.87]	B4	2.0
010	[00:15:56.27]	[00:15:59.47]	B1	3.0	010	[00:23:36.00]	[00:23:38.13]	B4	2.0
010	[00:16:13.33]	[00:16:22.40]	B1	9.0	010	[00:23:39.73]	[00:23:43.47]	B4	3.0
010	[00:16:24.00]	[00:16:32.00]	B1	8.0	010	[00:23:44.53]	[00:23:47.20]	B4	2.0
010	[00:16:33.60]	[00:16:40.00]	B1	6.0	010	[00:23:48.80]	[00:23:52.00]	B4	3.0
010	[00:16:42.67]	[00:16:48.00]	B1	5.0	010	[00:24:39.47]	[00:24:42.67]	B4	4.0
010	[00:16:51.20]	[00:16:57.07]	B1	6.0	010	[00:25:03.47]	[00:25:10.40]	B3	7.0
010	[00:16:59.73]	[00:17:04.53]	B1	5.0	010	[00:25:10.93]	[00:25:14.13]	B3	3.0
010	[00:17:07.20]	[00:17:12.00]	B1	5.0	010	[00:25:16.27]	[00:25:18.40]	B3	2.0
010	[00:17:26.93]	[00:17:32.80]	B1	6.0	010	[00:25:22.13]	[00:25:23.73]	B3	2.0
010	[00:17:34.93]	[00:17:39.73]	B1	5.0	010	[00:25:25.87]	[00:25:27.47]	B3	1.0
010	[00:17:42.40]	[00:17:47.20]	B1	5.0	010	[00:25:29.60]	[00:25:31.20]	B3	1.0
010	[00:17:49.33]	[00:17:52.53]	B1	4.0	010	[00:25:42.93]	[00:25:45.60]	B3	3.0
010	[00:17:56.80]	[00:18:01.60]	B1	5.0	010	[00:25:47.73]	[00:25:49.87]	B3	2.0
010	[00:18:05.33]	[00:18:08.53]	B1	4.0	010	[00:25:52.00]	[00:25:54.13]	B3	2.0
010	[00:18:12.27]	[00:18:16.00]	B1	4.0	010	[00:25:59.47]	[00:26:02.13]	B3	3.0
010	[00:18:19.20]	[00:18:21.87]	B1	3.0	010	[00:26:03.73]	[00:26:06.40]	B3	2.0
010	[00:18:40.53]	[00:18:42.67]	B4	2.0	010	[00:26:09.07]	[00:26:11.73]	B3	3.0
010	[00:18:45.33]	[00:18:48.53]	B4	4.0	011	[00:12:53.87]	[00:12:56.53]	B6	3.0
010	[00:18:52.27]	[00:18:54.93]	B4	3.0	011	[00:13:02.40]	[00:13:14.67]	B6	13.0
010	[00:18:58.13]	[00:19:00.27]	B4	2.0	011	[00:13:21.07]	[00:13:30.67]	B6	10.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
011	[00:13:34.40]	[00:13:43.47]	B6	9.0	011	[00:26:52.27]	[00:27:02.40]	B4	10.0
011	[00:13:52.00]	[00:14:01.07]	B6	9.0	011	[00:27:10.40]	[00:27:16.80]	B4	7.0
011	[00:14:03.20]	[00:14:16.53]	B6	14.0	011	[00:27:21.60]	[00:27:27.47]	B4	5.0
011	[00:14:21.33]	[00:14:32.53]	B3	12.0	011	[00:27:30.67]	[00:27:34.40]	B5	3.0
011	[00:14:39.47]	[00:14:48.53]	B3	10.0	011	[00:27:38.13]	[00:27:44.00]	B5	6.0
011	[00:14:58.67]	[00:15:08.27]	B6	9.0	011	[00:27:47.73]	[00:27:51.47]	B5	3.0
011	[00:15:14.13]	[00:15:25.87]	B6	12.0	011	[00:27:58.93]	[00:28:08.53]	B5	10.0
011	[00:15:28.00]	[00:15:37.60]	B6	10.0	011	[00:28:11.20]	[00:28:21.87]	B5	11.0
011	[00:15:43.47]	[00:15:53.60]	B7	11.0	011	[00:28:26.13]	[00:28:32.53]	B5	7.0
011	[00:16:05.87]	[00:16:14.93]	B7	9.0	011	[00:28:45.33]	[00:28:51.73]	B4	7.0
011	[00:16:21.87]	[00:16:32.53]	B7	11.0	011	[00:28:55.47]	[00:29:02.40]	B4	7.0
011	[00:16:34.13]	[00:16:40.53]	B7	7.0	011	[00:29:07.73]	[00:29:12.00]	B4	4.0
011	[00:16:40.53]	[00:16:48.00]	B6	7.0	011	[00:29:33.33]	[00:29:37.07]	B4	4.0
011	[00:16:49.60]	[00:17:00.80]	B7	11.0	011	[00:29:42.40]	[00:29:46.67]	B4	5.0
011	[00:17:01.87]	[00:17:05.07]	B6	3.0	011	[00:29:53.07]	[00:29:57.87]	B4	5.0
011	[00:17:08.80]	[00:17:20.00]	B7	11.0	011	[00:30:09.60]	[00:30:11.73]	B4	2.0
011	[00:17:24.80]	[00:17:34.40]	B7	9.0	011	[00:30:16.00]	[00:30:20.80]	B4	5.0
011	[00:17:36.53]	[00:17:41.87]	B7	5.0	011	[00:30:24.00]	[00:30:36.27]	B4	12.0
011	[00:17:56.27]	[00:18:07.47]	B7	11.0	011	[00:30:42.13]	[00:30:46.93]	B4	5.0
011	[00:18:11.20]	[00:18:14.93]	B7	4.0	011	[00:30:50.67]	[00:30:54.40]	B4	3.0
011	[00:18:21.87]	[00:18:32.00]	B7	10.0	011	[00:30:58.67]	[00:31:02.40]	B4	3.0
011	[00:18:35.20]	[00:18:41.60]	B7	7.0	011	[00:31:15.73]	[00:31:20.53]	B5	5.0
011	[00:18:44.27]	[00:18:49.60]	B7	6.0	011	[00:31:24.80]	[00:31:28.00]	B5	3.0
011	[00:18:50.13]	[00:18:53.33]	B6	3.0	011	[00:31:31.20]	[00:31:34.40]	B5	3.0
011	[00:18:58.67]	[00:19:05.60]	B7	7.0	011	[00:31:41.87]	[00:31:45.60]	B5	4.0
011	[00:19:13.60]	[00:19:18.93]	B3	5.0	011	[00:31:48.27]	[00:31:52.53]	B5	5.0
011	[00:19:24.27]	[00:19:30.13]	B6	6.0	011	[00:31:55.20]	[00:31:57.33]	B5	2.0
011	[00:19:31.20]	[00:19:43.47]	B7	12.0	011	[00:32:04.27]	[00:32:07.47]	B5	3.0
011	[00:20:02.67]	[00:20:12.27]	B4	9.0	002	[00:00:09.07]	[00:00:25.60]	C1	17.0
011	[00:20:14.40]	[00:20:23.47]	B4	9.0	002	[00:00:30.40]	[00:00:48.00]	C1	18.0
011	[00:20:30.93]	[00:20:38.40]	B3	7.0	002	[00:00:48.53]	[00:00:56.00]	C1	7.0
011	[00:20:41.60]	[00:20:48.00]	B4	6.0	002	[00:00:56.53]	[00:01:06.13]	C1	9.0
011	[00:20:56.00]	[00:21:01.33]	B4	5.0	002	[00:01:06.67]	[00:01:14.13]	C1	7.0
011	[00:21:05.07]	[00:21:08.27]	B4	3.0	002	[00:01:55.20]	[00:02:13.33]	C1	18.0
011	[00:21:12.53]	[00:21:17.87]	B4	5.0	002	[00:02:21.87]	[00:02:41.07]	C1	19.0
011	[00:21:20.00]	[00:21:23.73]	B4	4.0	002	[00:02:44.27]	[00:02:54.93]	C1	11.0
011	[00:21:26.93]	[00:21:32.80]	B4	6.0	002	[00:03:08.27]	[00:03:23.20]	C1	15.0
011	[00:21:42.40]	[00:21:46.13]	B7	4.0	002	[00:03:25.87]	[00:03:39.20]	C1	13.0
011	[00:21:48.27]	[00:21:52.00]	B4	4.0	002	[00:04:34.13]	[00:04:54.93]	C1	21.0
011	[00:21:56.80]	[00:22:03.20]	B3	6.0	002	[00:05:01.87]	[00:05:23.20]	C1	21.0
011	[00:22:04.80]	[00:22:10.13]	B4	5.0	002	[00:05:26.40]	[00:05:36.53]	C1	11.0
011	[00:22:14.40]	[00:22:20.80]	B3	7.0	002	[00:05:45.07]	[00:05:58.93]	C1	14.0
011	[00:22:25.07]	[00:22:28.80]	B4	4.0	002	[00:06:01.07]	[00:06:12.27]	C1	11.0
011	[00:22:34.67]	[00:22:40.00]	B3	5.0	002	[00:07:03.47]	[00:07:21.00]	C1	18.0
011	[00:22:42.67]	[00:22:47.47]	B4	4.0	002	[00:07:23.17]	[00:07:34.93]	C1	12.0
011	[00:22:53.87]	[00:23:01.33]	B3	7.0	002	[00:07:46.80]	[00:08:06.00]	C1	19.0
011	[00:23:03.47]	[00:23:07.73]	B4	5.0	002	[00:08:09.20]	[00:08:14.53]	C1	6.0
011	[00:23:12.53]	[00:23:18.93]	B3	6.0	002	[00:08:19.87]	[00:08:25.20]	C1	5.0
011	[00:23:22.67]	[00:23:25.33]	B4	2.0	002	[00:08:34.80]	[00:08:49.73]	C1	15.0
011	[00:23:30.13]	[00:23:36.00]	B4	6.0	002	[00:08:55.07]	[00:09:04.67]	C1	10.0
011	[00:23:37.07]	[00:23:40.80]	B4	4.0	002	[00:09:06.27]	[00:09:11.07]	C1	5.0
011	[00:23:46.13]	[00:23:52.00]	B4	6.0	002	[00:09:51.07]	[00:10:13.47]	C1	22.0
011	[00:24:00.00]	[00:24:10.13]	B4	10.0	002	[00:10:17.20]	[00:10:25.20]	C1	8.0
011	[00:24:19.20]	[00:24:29.33]	B7	10.0	002	[00:10:36.40]	[00:10:51.57]	C1	16.0
011	[00:25:08.27]	[00:25:18.93]	B5	11.0	002	[00:10:54.47]	[00:11:03.00]	C1	9.0
011	[00:25:25.87]	[00:25:36.00]	B5	10.0	002	[00:11:04.60]	[00:11:08.33]	C1	3.0
011	[00:25:44.53]	[00:25:47.20]	B5	2.0	002	[00:11:12.60]	[00:11:28.07]	C1	15.0
011	[00:25:53.60]	[00:25:56.80]	B5	3.0	002	[00:11:31.27]	[00:11:37.67]	C1	7.0
011	[00:26:02.13]	[00:26:10.67]	B5	9.0	002	[00:11:38.73]	[00:11:43.53]	C1	5.0
011	[00:26:34.13]	[00:26:40.53]	B4	7.0	002	[00:12:14.47]	[00:12:36.33]	C1	22.0
011	[00:26:44.80]	[00:26:49.07]	B4	4.0	002	[00:12:39.53]	[00:12:49.13]	C1	9.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
002	[00:12:59.80]	[00:13:15.80]	C1	16.0	002	[00:34:31.93]	[00:34:38.87]	C2	7.0
002	[00:13:18.47]	[00:13:21.67]	C1	4.0	002	[00:34:41.00]	[00:34:47.40]	C2	6.0
002	[00:13:30.20]	[00:13:40.87]	C1	11.0	002	[00:35:24.73]	[00:35:50.87]	C3	26.0
002	[00:13:44.07]	[00:13:51.53]	C1	8.0	002	[00:35:53.53]	[00:36:00.47]	C2	6.0
002	[00:14:02.20]	[00:14:21.40]	C1	19.0	002	[00:36:09.00]	[00:36:24.47]	C3	15.0
002	[00:14:25.67]	[00:14:32.60]	C1	7.0	002	[00:36:27.13]	[00:36:34.60]	C2	8.0
002	[00:14:41.13]	[00:14:50.30]	C1	9.0	002	[00:36:41.00]	[00:36:50.60]	C3	10.0
002	[00:14:54.40]	[00:15:02.60]	C1	9.0	002	[00:36:53.27]	[00:36:58.60]	C2	6.0
002	[00:15:41.30]	[00:16:13.87]	C2	33.0	002	[00:37:07.67]	[00:37:22.07]	C2	14.0
002	[00:16:17.07]	[00:16:25.07]	C2	8.0	002	[00:37:24.73]	[00:37:32.73]	C2	8.0
002	[00:16:34.67]	[00:16:50.13]	C2	15.0	002	[00:37:58.33]	[00:38:17.53]	C3	20.0
002	[00:16:52.27]	[00:16:59.73]	C2	8.0	002	[00:38:20.20]	[00:38:26.60]	C2	7.0
002	[00:17:07.73]	[00:17:20.53]	C2	13.0	002	[00:38:34.60]	[00:38:45.80]	C2	11.0
002	[00:17:23.73]	[00:17:32.27]	C2	8.0	002	[00:38:47.40]	[00:38:51.67]	C2	5.0
002	[00:17:38.13]	[00:17:56.27]	C2	18.0	002	[00:39:02.33]	[00:39:16.20]	C3	14.0
002	[00:17:58.93]	[00:18:04.27]	C2	5.0	002	[00:39:19.40]	[00:39:25.27]	C2	6.0
002	[00:18:09.07]	[00:18:18.13]	C2	9.0	002	[00:40:02.60]	[00:40:29.27]	C3	26.0
002	[00:18:20.80]	[00:18:28.27]	C2	7.0	002	[00:40:33.00]	[00:40:41.53]	C2	9.0
002	[00:19:10.93]	[00:19:25.87]	C2	15.0	002	[00:40:48.47]	[00:41:00.73]	C3	13.0
002	[00:19:28.53]	[00:19:34.40]	C2	5.0	002	[00:41:03.93]	[00:41:09.80]	C2	6.0
002	[00:19:48.27]	[00:20:02.67]	C2	15.0	002	[00:41:18.87]	[00:41:44.47]	C2	25.0
002	[00:20:06.40]	[00:20:16.53]	C2	11.0	002	[00:42:25.53]	[00:42:50.60]	C2	25.0
002	[00:20:26.13]	[00:20:38.93]	C2	13.0	002	[00:42:52.73]	[00:42:58.07]	C2	5.0
002	[00:20:41.60]	[00:20:49.07]	C2	7.0	002	[00:43:06.07]	[00:43:20.47]	C2	14.0
002	[00:20:54.93]	[00:21:08.27]	C2	13.0	002	[00:43:24.20]	[00:43:28.47]	C2	4.0
002	[00:21:13.07]	[00:21:21.60]	C2	9.0	002	[00:43:30.60]	[00:43:37.53]	C2	7.0
002	[00:21:27.47]	[00:21:37.60]	C2	11.0	002	[00:43:47.13]	[00:44:06.33]	C3	19.0
002	[00:21:41.33]	[00:21:47.73]	C2	7.0	002	[00:44:09.00]	[00:44:12.73]	C2	4.0
002	[00:22:22.93]	[00:22:42.67]	C2	20.0	002	[00:44:37.80]	[00:44:53.80]	C2	16.0
002	[00:22:45.87]	[00:22:50.67]	C2	5.0	002	[00:44:57.00]	[00:45:02.33]	C2	5.0
002	[00:23:01.87]	[00:23:14.13]	C2	12.0	002	[00:45:10.87]	[00:45:21.53]	C3	11.0
002	[00:23:17.87]	[00:23:25.33]	C2	7.0	002	[00:45:25.27]	[00:45:29.53]	C2	5.0
002	[00:23:36.00]	[00:23:48.27]	C2	12.0	002	[00:45:37.53]	[00:45:49.80]	C2	12.0
002	[00:23:50.40]	[00:23:56.27]	C2	6.0	002	[00:45:51.93]	[00:45:58.33]	C2	6.0
002	[00:24:14.93]	[00:24:28.80]	C2	14.0	002	[00:46:01.53]	[00:46:07.93]	C2	6.0
002	[00:24:31.47]	[00:24:40.00]	C2	9.0	002	[00:46:17.00]	[00:46:27.13]	C2	10.0
002	[00:24:52.27]	[00:25:04.23]	C2	12.0	002	[00:46:29.27]	[00:46:33.53]	C2	5.0
002	[00:26:07.40]	[00:26:25.53]	C2	19.0	002	[00:46:38.87]	[00:46:47.40]	C2	8.0
002	[00:26:28.20]	[00:26:32.47]	C2	4.0	002	[00:46:48.47]	[00:46:53.80]	C2	6.0
002	[00:26:41.00]	[00:26:55.93]	C2	15.0	002	[00:47:27.40]	[00:47:39.13]	C2	12.0
002	[00:26:59.13]	[00:27:05.00]	C2	6.0	002	[00:47:41.27]	[00:47:50.87]	C2	10.0
002	[00:27:13.00]	[00:27:24.20]	C2	11.0	002	[00:47:53.00]	[00:47:58.87]	C2	6.0
002	[00:27:27.40]	[00:27:32.73]	C2	6.0	002	[00:48:14.33]	[00:48:27.67]	C2	14.0
002	[00:27:41.27]	[00:27:56.20]	C2	15.0	002	[00:48:31.40]	[00:48:41.53]	C2	11.0
002	[00:27:59.40]	[00:28:05.27]	C2	6.0	002	[00:49:06.07]	[00:49:20.47]	C2	14.0
002	[00:28:17.00]	[00:28:30.87]	C2	14.0	002	[00:49:23.67]	[00:49:31.13]	C2	7.0
002	[00:28:32.47]	[00:28:38.87]	C2	7.0	002	[00:49:33.27]	[00:49:37.53]	C2	5.0
002	[00:29:28.47]	[00:29:56.73]	C2	29.0	002	[00:49:58.87]	[00:50:13.27]	C2	14.0
002	[00:29:59.40]	[00:30:04.20]	C2	5.0	002	[00:50:18.07]	[00:50:25.53]	C2	8.0
002	[00:30:12.73]	[00:30:32.47]	C2	19.0	002	[00:50:38.87]	[00:50:51.13]	C2	12.0
002	[00:30:34.60]	[00:30:39.40]	C2	4.0	002	[00:50:54.33]	[00:51:00.20]	C2	6.0
002	[00:30:42.60]	[00:30:52.20]	C2	9.0	002	[00:51:06.07]	[00:51:11.93]	C2	6.0
002	[00:31:03.40]	[00:31:23.67]	C2	21.0	002	[00:51:31.13]	[00:51:44.47]	C2	13.0
002	[00:31:26.33]	[00:31:32.20]	C2	6.0	002	[00:51:47.13]	[00:51:53.53]	C2	7.0
002	[00:31:35.93]	[00:31:39.67]	C2	4.0	002	[00:52:13.27]	[00:52:23.93]	C2	11.0
002	[00:32:31.40]	[00:32:50.07]	C3	19.0	002	[00:52:27.67]	[00:52:33.00]	C2	5.0
002	[00:32:54.33]	[00:33:07.67]	C3	14.0	002	[00:52:37.27]	[00:52:43.67]	C2	7.0
002	[00:33:21.00]	[00:33:34.87]	C3	14.0	002	[00:52:58.07]	[00:53:10.33]	C2	12.0
002	[00:33:37.53]	[00:33:43.40]	C2	5.0	002	[00:53:12.47]	[00:53:18.87]	C2	7.0
002	[00:33:45.53]	[00:33:51.93]	C2	6.0	002	[00:53:21.00]	[00:53:27.40]	C2	6.0
002	[00:34:12.20]	[00:34:29.80]	C2	18.0	002	[00:53:47.67]	[00:54:01.00]	C2	13.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
002	[00:54:05.80]	[00:54:11.13]	C4	5.0	002	[00:32:20.90]	[00:32:44.37]	D2	23.0
002	[00:54:13.80]	[00:54:18.60]	C2	5.0	002	[00:32:45.43]	[00:32:57.17]	D5	12.0
002	[00:54:30.33]	[00:54:45.27]	C2	15.0	002	[00:32:57.70]	[00:33:41.43]	D2	43.0
002	[00:54:49.53]	[00:54:57.00]	C2	7.0	002	[00:33:42.50]	[00:33:55.83]	D5	13.0
002	[00:55:56.20]	[00:56:11.13]	C2	15.0	002	[00:33:56.90]	[00:36:32.20]	D2	155.0
002	[00:56:14.87]	[00:56:25.00]	C2	10.0	002	[00:36:36.47]	[00:36:47.77]	D5	12.0
002	[00:56:45.27]	[00:57:01.80]	C2	17.0	002	[00:36:50.43]	[00:37:28.83]	D3	39.0
002	[00:57:07.13]	[00:57:17.27]	C2	10.0	002	[00:37:29.37]	[00:37:42.70]	D2	14.0
002	[00:57:39.67]	[00:58:01.00]	C2	21.0	002	[00:37:47.33]	[00:37:55.33]	D3	8.0
002	[00:58:03.67]	[00:58:14.87]	C2	11.0	002	[00:37:55.87]	[00:37:58.53]	D2	3.0
002	[00:58:34.07]	[00:58:49.00]	C2	15.0	002	[00:38:07.60]	[00:38:58.27]	D2	50.0
002	[00:58:52.73]	[00:58:59.67]	C2	7.0	002	[00:39:03.60]	[00:40:11.70]	D2	68.0
002	[00:59:24.73]	[00:59:39.13]	C2	14.0	002	[00:40:22.37]	[00:40:42.10]	D3	20.0
002	[00:59:42.87]	[00:59:48.73]	C2	6.0	002	[00:40:43.17]	[00:40:58.73]	D2	16.0
001	[00:31:48.30]	[00:32:14.90]	D1	27.0	002	[00:41:03.23]	[00:42:43.13]	D2	100.0
001	[00:32:16.14]	[00:32:54.67]	D2	39.0	002	[00:42:46.93]	[00:43:56.13]	D2	69.0
001	[00:33:09.25]	[00:34:16.67]	D2	68.0	002	[00:43:59.33]	[00:44:01.47]	D3	2.0
001	[00:34:21.04]	[00:37:58.14]	D2	217.0	003	[00:16:26.67]	[00:17:15.20]	D5	48.0
001	[00:37:59.43]	[00:38:06.68]	D1	8.0	003	[00:17:20.53]	[00:17:40.80]	D1	20.0
001	[00:38:07.76]	[00:39:28.63]	D2	81.0	003	[00:17:41.87]	[00:18:55.47]	D2	73.0
001	[00:39:30.07]	[00:39:45.85]	D1	16.0	003	[00:18:59.20]	[00:19:37.60]	D2	39.0
001	[00:39:46.83]	[00:40:59.38]	D2	72.0	003	[00:19:47.20]	[00:21:44.53]	D2	118.0
001	[00:41:00.71]	[00:42:00.23]	D2	59.0	003	[00:21:46.13]	[00:21:54.13]	D1	8.0
001	[00:42:11.34]	[00:43:31.77]	D2	81.0	003	[00:21:55.73]	[00:22:09.60]	D5	14.0
001	[00:43:38.77]	[00:43:44.40]	D3	5.0	003	[00:22:09.60]	[00:23:37.07]	D2	87.0
001	[00:43:47.67]	[00:43:51.28]	D3	3.0	003	[00:23:38.13]	[00:23:42.40]	D1	4.0
001	[00:43:56.99]	[00:44:29.87]	D2	33.0	003	[00:23:43.47]	[00:25:03.47]	D2	80.0
001	[00:45:42.66]	[00:45:59.19]	D3	16.0	003	[00:25:04.00]	[00:25:09.87]	D1	6.0
001	[00:46:03.31]	[00:47:30.01]	D2	87.0	003	[00:25:13.07]	[00:25:17.33]	D5	4.0
001	[00:47:49.50]	[00:48:20.19]	D4	30.0	003	[00:25:18.40]	[00:26:22.93]	D2	65.0
001	[00:48:29.48]	[00:49:08.31]	D4	39.0	003	[00:26:29.33]	[00:26:45.33]	D1	16.0
001	[00:49:16.41]	[00:49:25.46]	D4	9.0	003	[00:26:45.87]	[00:27:40.27]	D3	54.0
001	[00:49:26.92]	[00:49:33.70]	D4	7.0	003	[00:27:42.40]	[00:27:54.13]	D2	12.0
001	[00:49:49.04]	[00:49:59.26]	D4	10.0	003	[00:27:58.93]	[00:28:02.13]	D2	3.0
001	[00:50:00.57]	[00:50:09.52]	D4	9.0	003	[00:28:10.13]	[00:28:47.47]	D3	37.0
001	[00:50:14.71]	[00:50:26.18]	D4	11.0	003	[00:28:52.80]	[00:28:58.13]	D2	5.0
001	[00:50:30.45]	[00:50:43.66]	D4	14.0	003	[00:28:59.20]	[00:29:23.73]	D3	25.0
001	[00:50:45.39]	[00:50:50.65]	D4	6.0	003	[00:29:27.47]	[00:29:45.07]	D1	18.0
001	[00:51:07.23]	[00:51:12.45]	D4	5.0	003	[00:29:45.60]	[00:29:56.27]	D5	10.0
001	[00:51:13.62]	[00:51:20.68]	D4	7.0	003	[00:30:00.00]	[00:30:41.60]	D2	42.0
001	[00:51:22.93]	[00:51:29.14]	D4	6.0	003	[00:30:45.33]	[00:32:11.73]	D3	87.0
001	[00:51:34.14]	[00:51:41.37]	D4	7.0	007	[00:20:21.87]	[00:20:53.87]	D6	32.0
001	[00:51:47.38]	[00:51:54.07]	D4	7.0	007	[00:20:57.60]	[00:22:39.47]	D2	101.0
001	[00:51:56.08]	[00:52:02.66]	D4	7.0	007	[00:22:48.00]	[00:22:58.67]	D3	11.0
001	[00:52:07.55]	[00:52:21.75]	D4	14.0	007	[00:22:59.73]	[00:23:13.07]	D2	13.0
001	[00:52:28.78]	[00:52:35.71]	D4	7.0	007	[00:23:14.13]	[00:23:20.00]	D3	6.0
001	[00:52:39.19]	[00:52:50.13]	D4	11.0	007	[00:23:22.67]	[00:23:33.33]	D2	10.0
001	[00:52:51.78]	[00:52:56.29]	D4	4.0	007	[00:24:03.20]	[00:24:23.47]	D2	20.0
001	[00:53:07.37]	[00:53:11.35]	D4	4.0	007	[00:24:24.00]	[00:24:45.87]	D2	22.0
001	[00:53:13.82]	[00:53:18.11]	D4	4.0	007	[00:24:50.67]	[00:25:42.93]	D3	52.0
001	[00:53:23.57]	[00:53:33.57]	D4	10.0	007	[00:25:57.33]	[00:26:04.27]	D6	7.0
001	[00:53:35.45]	[00:53:39.75]	D4	5.0	007	[00:26:05.33]	[00:26:16.53]	D2	12.0
001	[00:53:44.42]	[00:53:51.34]	D4	7.0	007	[00:26:17.07]	[00:26:24.53]	D6	8.0
001	[00:53:56.18]	[00:54:04.21]	D4	8.0	007	[00:26:25.60]	[00:26:38.40]	D2	12.0
001	[00:54:05.79]	[00:54:09.56]	D4	4.0	007	[00:26:43.20]	[00:27:09.87]	D3	27.0
001	[00:54:13.76]	[00:54:29.15]	D4	15.0	007	[00:27:16.27]	[00:27:36.53]	D3	21.0
001	[00:54:38.75]	[00:54:41.85]	D4	3.0	007	[00:27:42.40]	[00:28:15.47]	D2	33.0
001	[00:54:49.83]	[00:54:56.75]	D4	7.0	007	[00:28:58.13]	[00:29:13.07]	D3	15.0
001	[00:54:58.14]	[00:55:05.28]	D4	7.0	007	[00:29:14.13]	[00:29:40.27]	D2	26.0
002	[00:31:45.70]	[00:32:00.63]	D1	15.0	007	[00:29:40.80]	[00:29:46.13]	D3	5.0
002	[00:32:04.37]	[00:32:19.83]	D5	16.0	007	[00:29:46.67]	[00:29:54.13]	D2	7.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
007	[00:30:00.00]	[00:30:05.33]	D2	5.0	011	[00:24:11.20]	[00:24:13.87]	D1	3.0
007	[00:30:11.73]	[00:30:21.87]	D6	10.0	011	[00:24:16.00]	[00:24:29.33]	D4	13.0
007	[00:30:23.47]	[00:30:30.93]	D2	8.0	011	[00:24:32.00]	[00:24:43.73]	D4	12.0
007	[00:30:31.47]	[00:30:39.47]	D3	8.0	011	[00:24:45.87]	[00:24:56.53]	D4	11.0
011	[00:07:21.60]	[00:11:27.47]	D5	245.0	011	[00:25:01.33]	[00:25:11.47]	D5	10.0
011	[00:11:50.40]	[00:12:34.13]	D1	44.0	011	[00:25:14.13]	[00:25:23.20]	D5	9.0
011	[00:12:36.27]	[00:12:43.20]	D6	7.0	011	[00:25:26.40]	[00:25:29.60]	D1	4.0
011	[00:12:45.33]	[00:12:54.93]	D6	10.0	011	[00:25:31.20]	[00:25:40.80]	D4	10.0
011	[00:12:58.13]	[00:13:12.00]	D6	14.0	011	[00:25:44.00]	[00:25:57.87]	D4	14.0
011	[00:13:27.47]	[00:13:33.87]	D6	7.0	011	[00:26:00.53]	[00:26:10.67]	D5	10.0
011	[00:13:36.53]	[00:13:48.27]	D6	11.0	011	[00:26:16.00]	[00:26:27.20]	D4	11.0
011	[00:13:52.53]	[00:13:58.93]	D6	6.0	011	[00:26:29.33]	[00:26:37.87]	D5	9.0
011	[00:14:01.60]	[00:14:06.93]	D6	5.0	011	[00:26:40.53]	[00:26:44.80]	D4	4.0
011	[00:14:09.07]	[00:14:13.33]	D6	4.0	011	[00:26:48.53]	[00:26:52.80]	D5	4.0
011	[00:14:17.60]	[00:14:49.07]	D1	31.0	011	[00:26:54.93]	[00:26:58.67]	D5	4.0
011	[00:14:50.13]	[00:15:12.00]	D6	22.0	011	[00:27:00.27]	[00:27:04.53]	D5	5.0
011	[00:15:14.67]	[00:15:30.67]	D6	16.0	011	[00:27:06.13]	[00:27:08.80]	D5	3.0
011	[00:15:33.87]	[00:15:53.07]	D6	19.0	011	[00:27:25.87]	[00:27:36.00]	D5	10.0
011	[00:15:54.67]	[00:16:03.20]	D6	8.0	011	[00:27:39.20]	[00:27:52.00]	D5	13.0
011	[00:16:07.47]	[00:16:13.33]	D6	6.0	011	[00:27:54.13]	[00:28:00.53]	D5	7.0
011	[00:16:16.00]	[00:16:25.07]	D6	9.0	011	[00:28:09.07]	[00:28:19.20]	D5	10.0
011	[00:16:27.20]	[00:16:32.53]	D6	6.0	011	[00:28:21.87]	[00:28:29.33]	D5	7.0
011	[00:16:36.27]	[00:16:42.67]	D6	7.0	011	[00:28:32.53]	[00:28:40.00]	D5	7.0
011	[00:16:48.00]	[00:17:00.80]	D1	13.0	011	[00:28:42.13]	[00:28:46.40]	D1	4.0
011	[00:17:05.60]	[00:17:19.47]	D6	13.0	011	[00:28:49.07]	[00:28:57.60]	D5	9.0
011	[00:17:22.13]	[00:17:32.27]	D6	10.0	011	[00:29:00.27]	[00:29:06.67]	D5	7.0
011	[00:17:36.53]	[00:17:51.47]	D6	14.0	011	[00:29:09.33]	[00:29:15.73]	D5	7.0
011	[00:17:54.67]	[00:18:05.87]	D6	11.0	011	[00:29:24.27]	[00:29:33.33]	D5	9.0
011	[00:18:08.00]	[00:18:14.40]	D6	6.0	011	[00:29:36.53]	[00:29:41.87]	D5	5.0
011	[00:18:18.67]	[00:18:30.93]	D6	12.0	011	[00:29:43.47]	[00:29:48.27]	D1	5.0
011	[00:18:33.60]	[00:18:44.27]	D6	10.0	011	[00:29:51.47]	[00:30:16.00]	D5	25.0
011	[00:18:45.87]	[00:18:53.33]	D6	7.0	011	[00:30:22.93]	[00:30:47.47]	D5	24.0
011	[00:18:56.00]	[00:19:01.87]	D6	6.0	011	[00:30:52.80]	[00:31:13.60]	D5	21.0
011	[00:19:05.60]	[00:19:12.00]	D1	6.0	011	[00:31:17.33]	[00:31:23.20]	D5	6.0
011	[00:19:12.53]	[00:19:25.87]	D6	13.0	011	[00:31:25.33]	[00:31:31.73]	D5	7.0
011	[00:19:28.53]	[00:19:40.27]	D6	11.0	011	[00:31:37.07]	[00:31:39.73]	D5	3.0
011	[00:19:42.93]	[00:19:49.33]	D6	6.0	007	[00:00:17.60]	[00:00:26.13]	D4	8.0
011	[00:19:53.07]	[00:20:02.67]	D6	10.0	007	[00:00:27.73]	[00:00:42.67]	D4	15.0
011	[00:20:05.33]	[00:20:13.87]	D6	9.0	007	[00:00:43.20]	[00:00:50.13]	D1	7.0
011	[00:20:18.13]	[00:20:25.07]	D1	7.0	007	[00:00:52.80]	[00:01:04.00]	D4	11.0
011	[00:20:26.67]	[00:20:38.93]	D6	12.0	007	[00:01:05.07]	[00:01:12.00]	D4	7.0
011	[00:20:41.60]	[00:20:50.13]	D6	8.0	007	[00:01:14.67]	[00:01:22.13]	D4	7.0
011	[00:20:52.80]	[00:21:09.33]	D6	16.0	007	[00:01:23.73]	[00:01:30.13]	D4	6.0
011	[00:21:10.93]	[00:21:15.73]	D6	5.0	007	[00:01:31.73]	[00:01:40.27]	D4	8.0
011	[00:21:21.60]	[00:21:27.47]	D1	5.0	007	[00:01:43.47]	[00:01:58.40]	D1	15.0
011	[00:21:30.13]	[00:21:41.87]	D6	12.0	007	[00:02:00.53]	[00:02:12.27]	D10	11.0
011	[00:21:44.53]	[00:21:51.47]	D6	6.0	007	[00:02:14.40]	[00:02:22.93]	D4	9.0
011	[00:21:52.53]	[00:22:00.00]	D6	7.0	007	[00:02:27.20]	[00:02:38.40]	D4	11.0
011	[00:22:01.60]	[00:22:11.73]	D6	10.0	007	[00:02:43.20]	[00:02:51.73]	D4	9.0
011	[00:22:13.33]	[00:22:16.00]	D6	3.0	007	[00:02:55.47]	[00:03:12.00]	D4	17.0
011	[00:22:16.53]	[00:22:19.20]	D6	2.0	007	[00:03:18.40]	[00:03:32.27]	D4	14.0
011	[00:22:21.87]	[00:22:37.87]	D5	16.0	007	[00:03:40.80]	[00:03:49.33]	D4	8.0
011	[00:22:41.07]	[00:22:48.53]	D5	8.0	007	[00:03:54.67]	[00:04:04.80]	D4	10.0
011	[00:22:52.80]	[00:22:58.13]	D1	5.0	007	[00:04:11.20]	[00:04:21.87]	D4	11.0
011	[00:23:00.80]	[00:23:11.47]	D5	10.0	007	[00:04:24.53]	[00:04:33.07]	D4	8.0
011	[00:23:13.07]	[00:23:20.53]	D5	8.0	007	[00:04:34.67]	[00:04:42.67]	D4	8.0
011	[00:23:23.20]	[00:23:27.47]	D5	4.0	007	[00:04:47.47]	[00:04:56.00]	D4	9.0
011	[00:23:30.13]	[00:23:39.20]	D5	9.0	007	[00:05:01.87]	[00:05:14.13]	D4	12.0
011	[00:23:41.87]	[00:23:47.73]	D5	6.0	007	[00:05:16.80]	[00:05:21.07]	D1	4.0
011	[00:23:50.40]	[00:23:59.47]	D5	9.0	007	[00:05:22.67]	[00:05:29.60]	D10	7.0
011	[00:24:02.13]	[00:24:06.93]	D5	5.0	007	[00:05:31.73]	[00:05:39.20]	D4	7.0

ID	Start Time	End Time	Code	Duration (sec)	ID	Start Time	End Time	Code	Duration (sec)
007	[00:05:41.33]	[00:05:51.47]	D4	10.0	012	[00:19:50.40]	[00:19:58.40]	B7	8.0
007	[00:05:56.27]	[00:06:03.73]	D10	8.0	012	[00:20:02.13]	[00:20:07.47]	B7	5.0
007	[00:06:08.53]	[00:06:16.00]	D4	7.0	012	[00:20:13.87]	[00:20:20.80]	B7	7.0
007	[00:06:26.67]	[00:06:30.93]	D11	4.0	012	[00:20:20.80]	[00:20:26.67]	B6	6.0
007	[00:06:32.00]	[00:06:43.20]	D11	11.0	012	[00:21:12.00]	[00:21:16.80]	B7	5.0
007	[00:06:46.93]	[00:06:58.67]	D4	12.0	012	[00:21:20.00]	[00:21:36.00]	B7	16.0
007	[00:06:59.73]	[00:07:09.33]	D4	9.0	012	[00:21:42.93]	[00:21:47.20]	B7	4.0
007	[00:07:12.53]	[00:07:21.07]	D4	8.0	007	[00:21:52.00]	[00:21:58.40]	B7	6.0
007	[00:07:23.20]	[00:07:33.87]	D4	11.0	007	[00:22:07.47]	[00:22:12.80]	B4	6.0
007	[00:07:37.60]	[00:07:52.00]	D4	14.0	007	[00:22:18.67]	[00:22:22.93]	B7	4.0
007	[00:07:56.80]	[00:08:03.73]	D4	7.0	007	[00:22:30.40]	[00:22:38.40]	B7	8.0
007	[00:08:06.40]	[00:08:21.33]	D4	15.0	007	[00:22:59.73]	[00:23:07.20]	B2	7.0
007	[00:08:26.67]	[00:08:32.53]	D4	6.0	007	[00:23:09.87]	[00:23:12.53]	B7	3.0
007	[00:08:36.80]	[00:08:46.40]	D4	9.0	007	[00:23:15.73]	[00:23:20.00]	B7	4.0
007	[00:08:49.07]	[00:09:01.87]	D4	13.0	007	[00:23:24.27]	[00:23:26.93]	B7	3.0
012	[00:09:15.73]	[00:09:38.67]	B2	23.0	007	[00:23:35.47]	[00:23:39.20]	B7	4.0
012	[00:09:44.53]	[00:09:57.87]	B7	13.0	007	[00:23:48.80]	[00:23:56.27]	B7	7.0
012	[00:10:01.60]	[00:10:15.47]	B7	13.0	007	[00:24:13.33]	[00:24:27.20]	B7	14.0
012	[00:10:28.80]	[00:10:38.93]	B7	10.0	007	[00:24:31.47]	[00:24:33.60]	B7	3.0
012	[00:10:42.13]	[00:10:52.27]	B7	10.0	007	[00:24:39.47]	[00:24:41.60]	B7	3.0
012	[00:10:56.00]	[00:11:05.60]	B7	10.0	007	[00:24:43.73]	[00:24:47.47]	B7	3.0
012	[00:11:09.33]	[00:11:20.00]	B7	11.0	007	[00:24:58.13]	[00:25:02.40]	B7	4.0
012	[00:11:24.27]	[00:11:38.67]	B2	15.0	007	[00:25:06.67]	[00:25:09.87]	B7	3.0
012	[00:11:45.60]	[00:12:05.87]	B7	20.0	007	[00:25:14.13]	[00:25:19.47]	B7	5.0
012	[00:12:10.13]	[00:12:18.67]	B7	9.0	007	[00:25:22.13]	[00:25:28.00]	B7	6.0
012	[00:12:23.47]	[00:12:30.93]	B7	8.0	007	[00:25:30.13]	[00:25:33.33]	B7	3.0
012	[00:12:37.33]	[00:12:50.67]	B7	14.0	007	[00:25:41.87]	[00:25:46.13]	B7	4.0
012	[00:12:54.93]	[00:13:02.40]	B7	7.0	007	[00:25:49.33]	[00:25:52.53]	B7	4.0
012	[00:13:09.33]	[00:13:16.80]	B7	8.0	007	[00:26:02.13]	[00:26:05.33]	B7	3.0
012	[00:13:17.87]	[00:13:29.07]	B7	11.0	007	[00:26:10.67]	[00:26:13.87]	B7	3.0
012	[00:13:30.67]	[00:13:40.27]	B7	9.0	007	[00:26:21.87]	[00:26:24.53]	B7	3.0
012	[00:13:42.40]	[00:13:47.20]	B6	5.0	007	[00:26:35.73]	[00:26:38.93]	B7	3.0
012	[00:13:49.33]	[00:14:08.53]	B2	20.0	007	[00:26:42.13]	[00:26:46.93]	B7	5.0
012	[00:14:11.73]	[00:14:20.80]	B7	9.0	007	[00:27:07.20]	[00:28:13.33]	A1	66.0
012	[00:14:24.53]	[00:14:36.27]	B7	11.0	007	[00:28:14.40]	[00:29:13.07]	A3	59.0
012	[00:14:38.93]	[00:14:51.20]	B7	12.0	007	[00:29:13.60]	[00:29:44.53]	A2	31.0
012	[00:14:56.00]	[00:15:04.00]	B7	8.0	007	[00:29:46.67]	[00:29:54.67]	A3	8.0
012	[00:15:07.20]	[00:15:22.13]	B7	15.0	007	[00:29:55.73]	[00:30:28.27]	A2	32.0
012	[00:15:24.27]	[00:15:31.73]	B7	8.0	007	[00:30:52.27]	[00:31:40.80]	A1	49.0
012	[00:15:35.47]	[00:15:45.60]	B7	11.0	007	[00:31:42.40]	[00:33:21.60]	A3	100.0
012	[00:15:50.93]	[00:15:59.47]	B7	8.0	007	[00:33:22.67]	[00:33:26.93]	A2	4.0
012	[00:16:00.00]	[00:16:06.40]	B6	6.0	007	[00:33:27.47]	[00:33:36.00]	A3	9.0
012	[00:16:08.53]	[00:16:22.40]	B2	13.0	007	[00:33:39.20]	[00:34:54.93]	A2	76.0
012	[00:16:25.60]	[00:16:36.80]	B7	11.0	007	[00:35:05.60]	[00:36:05.33]	D5	59.0
012	[00:16:42.67]	[00:16:49.60]	B7	7.0	007	[00:36:08.53]	[00:36:47.47]	D1	38.0
012	[00:16:53.33]	[00:17:03.47]	B7	10.0	007	[00:36:54.40]	[00:37:21.07]	D4	27.0
012	[00:17:07.20]	[00:17:14.67]	B7	8.0	007	[00:37:22.13]	[00:37:32.27]	D4	10.0
012	[00:17:20.00]	[00:17:26.93]	B7	7.0	007	[00:37:33.87]	[00:37:57.87]	D4	24.0
012	[00:17:29.07]	[00:17:40.80]	B7	12.0	007	[00:37:59.47]	[00:38:06.93]	D4	8.0
012	[00:17:44.53]	[00:17:52.00]	B7	7.0	007	[00:38:15.47]	[00:38:52.27]	D4	37.0
012	[00:17:52.53]	[00:18:01.60]	B7	9.0	007	[00:38:54.40]	[00:39:04.53]	D4	11.0
012	[00:18:09.07]	[00:18:11.73]	B2	3.0	007	[00:39:11.47]	[00:39:37.07]	D4	26.0
012	[00:18:12.80]	[00:18:20.27]	B7	7.0	007	[00:39:39.73]	[00:40:11.20]	D4	31.0
012	[00:18:22.40]	[00:18:30.93]	B7	9.0	007	[00:40:27.20]	[00:40:58.13]	D4	31.0
012	[00:18:33.07]	[00:18:36.80]	B7	4.0	007	[00:41:04.00]	[00:41:25.33]	D4	21.0
012	[00:18:38.40]	[00:18:46.40]	B7	8.0	007	[00:41:29.60]	[00:41:52.00]	D4	22.0
012	[00:18:50.13]	[00:18:57.07]	B7	7.0	007	[00:41:54.67]	[00:42:08.53]	D4	14.0
012	[00:19:03.47]	[00:19:12.00]	B7	9.0	007	[00:42:10.67]	[00:42:18.13]	D4	7.0
012	[00:19:14.13]	[00:19:21.60]	B7	8.0	007	[00:42:23.47]	[00:42:56.00]	D4	33.0
012	[00:19:24.80]	[00:19:34.40]	B7	9.0	007	[00:42:58.67]	[00:43:09.33]	D4	10.0
012	[00:19:38.13]	[00:19:47.20]	B7	9.0	007	[00:43:13.07]	[00:43:37.07]	D4	24.0

ID	Start Time	End Time	Code	Duration (sec)
007	[00:43:38.13]	[00:43:44.00]	D4	6.0
007	[00:43:52.53]	[00:44:30.93]	D4	38.0
007	[00:44:33.07]	[00:45:01.87]	D4	29.0
007	[00:45:06.67]	[00:45:13.60]	D4	7.0
007	[00:45:20.00]	[00:45:39.73]	D4	20.0
007	[00:45:41.87]	[00:45:58.40]	D4	16.0
007	[00:46:01.07]	[00:46:10.13]	D4	9.0
007	[00:46:11.73]	[00:46:20.80]	D4	9.0
007	[00:46:25.07]	[00:46:34.67]	D4	10.0
007	[00:46:40.00]	[00:47:16.80]	D4	37.0
007	[00:47:21.07]	[00:47:25.87]	D4	5.0
007	[00:47:31.20]	[00:47:55.73]	D10	25.0
007	[00:47:56.80]	[00:48:02.13]	D4	5.0
007	[00:48:03.20]	[00:48:10.13]	D4	7.0
007	[00:48:12.80]	[00:48:20.27]	D4	7.0
007	[00:48:26.67]	[00:48:41.60]	D5	15.0
007	[00:48:43.20]	[00:49:26.93]	D10	44.0
007	[00:49:31.73]	[00:49:38.13]	D4	6.0
007	[00:49:42.93]	[00:50:04.80]	D10	22.0
007	[00:50:08.53]	[00:50:14.40]	D4	5.0
007	[00:50:18.67]	[00:50:24.53]	D4	6.0
007	[00:50:45.33]	[00:51:07.73]	D4	23.0
007	[00:51:09.33]	[00:51:24.27]	D4	15.0
007	[00:51:29.07]	[00:51:45.60]	D4	17.0
007	[00:51:53.07]	[00:52:18.13]	D10	25.0
007	[00:52:20.80]	[00:52:42.67]	D4	22.0
007	[00:52:46.93]	[00:53:03.47]	D10	16.0
007	[00:53:06.13]	[00:53:14.13]	D10	8.0
007	[00:53:16.27]	[00:53:33.33]	D4	17.0
007	[00:53:36.53]	[00:53:46.13]	D4	9.0
007	[00:53:48.27]	[00:53:56.80]	D4	9.0
007	[00:54:01.07]	[00:54:07.47]	D10	6.0
007	[00:54:09.07]	[00:54:18.13]	D4	9.0
007	[00:54:19.73]	[00:54:27.20]	D4	7.0
007	[00:54:34.13]	[00:54:46.40]	D4	12.0
007	[00:54:55.47]	[00:55:11.47]	D1	16.0
007	[00:55:17.33]	[00:55:26.93]	D2	10.0
007	[00:55:28.53]	[00:56:46.93]	D4	78.0
007	[00:56:48.53]	[00:57:30.67]	D5	42.0
007	[00:57:36.53]	[00:58:49.07]	D4	72.0
007	[00:58:50.13]	[00:59:00.80]	D3	11.0
007	[00:59:02.40]	[00:59:25.33]	D4	23.0
007	[00:59:25.87]	[00:59:43.47]	D3	17.0
007	[00:59:44.53]	[00:59:52.00]	D4	7.0
007	[00:59:57.33]	[01:01:14.67]	D5	78.0

Appendix G: Research Project Approval Form of HREC (Human Research Ethics Committee)

FACULTY OF ART AND DESIGN
HUMAN RESEARCH ETHICS COMMITTEE

Research Project Approval Form

A) Project Title:

A study of work injuries and an assessment of them in relation to the hairdressing industry, based on human factors in the workplace.

B) Student Name(s):

Lynn, Hsiao-Lin Fang

C) Programme of Study:

PhD Research

D) Student Signature:

Hsiao-Lin Fang

E) Supervisor Name(s):

First Supervisor: Dr. Robert Chen, Faculty of Art and Design
Second Supervisor: Ms. Julie King, Faculty of Art and Design
Dr. Qing Xu, Faculty of Health and Life Science

F) First Supervisor's Signature:

For office use only:

Date received:	20 SEP 2005
FHREC meeting:	CA.
Form number:	0110

COMMITTEE RECOMMENDATION:

1. No ethical issues:	
2. Minor ethical issues which have been addressed and concerns resolved:	✓
3. Major ethical issues which have been addressed and concerns resolved:	
4. Ethical issues that have not been resolved:	
Committee guidance:	

Approval Signature ....
Chair of Faculty Human Research Ethics Committee

Please refer to the guidance notes when completing these sections.

SECTION 1: Statement of Research Objectives:

The objectives with related methods are:

1. To identify and review the relevant literature relating to development of hairdressing, vocational education training, job description of hairdressing, occupational ergonomics, human factors, work injuries, risk factors in the hairdressing industry, relevant professional bodies.
2. To interview experts to gain advisory opinions on the questionnaire design, and then question hairdressers as a pilot study in the workplace for the current situation in order to identify the risk factors for case study.
3. To observe the potential crises arising from work injuries in the hairdressing industry and among hairdressers, based on observations in terms of the anthropometric assessment of salon environment, working posture, work-procedures, instruments, tools, and equipment.
4. To question hairdressers based on the Baseline Risk Identification of Ergonomics Factors (BRIEF) form and the Nordic Musculoskeletal Questionnaire (NMQ) form following observation.
5. To evaluate and identify research findings with the survey data and subsequent analysis.
6. To contribute perceptions of preventing work injuries in the hairdressing industry within the evaluation resulting from case study, (Refer 2 to 5) and in the ultimate part to draw conclusion and recommendation.
7. * The MPhil/PhD transfer will be made at the completion of stage 1.

SECTION 2: Rationale for undertaking the study:

The aim of this research is to investigate risk factors leading to work injuries in the hairdressing industry through observation in terms of the anthropometric assessment of hairdressers in the workplace, job analysis, working posture, work-procedures, equipment, and tools used. Moreover, the researcher will investigate the potential crises stemming from job injuries, based on identification and the evaluation of human factors among hairdressers in their workplaces.

SECTION 3: Statement on research procedures and methodologies:

This research will concentrate on the study of work injuries and their ergonomics assessment, which will counter potential crises arising from job injuries among hairdressers in their workplaces. Moreover, it is hoped that this study conducted in the UK and Taiwan will stimulate related research and development in the related professional bodies.

Conducted research will comprise literature review, observation, interviews, assessment, case studies, and surveys as follows:

Firstly, to interview experts to gain advisory opinion on the questionnaire design and then question hairdressers as a pilot study in the workplace for the current situation in order to identify the risk factors for case study.

Secondly, the primary research will carry out observation of potential crises due to work injuries in the hairdressing industry and among hairdressers, based on observation in terms of the anthropometric assessment of salon environment, working posture, work-procedure, instruments, tools, and equipment.

Thirdly, a questionnaire survey will be carried out to obtain the quantitative data from hairdressers, based on the Baseline Risk Identification of Ergonomics Factors (BRIEF) form and the Nordic Musculoskeletal Questionnaire (NMQ) sheet.

Then, to evaluate and identify research findings by the survey data and subsequent analysis.

Finally, to draw conclusion and recommendation to contribute ideas to prevent work injuries in the hairdressing industry.

SECTION 4: Arrangements for participation of human subjects, including recruitment, consent and confidentiality procedures and documentation:

All proposed methods involved with communication and human participation would be conducted in a professional manner with care and respect afforded to all individuals concerned.

In cooperation with participants, the researcher will ask for permission from participants through formal documents before the research progresses and present an introduction to and outline of the research for the participants in advance and during the study if the participants choose to withdraw from this study at any time for any reason, not be used in the analysis unless removal of the data is logistically.

Participant in this research will be kept confidential by the researcher. The researcher himself will do all transcription work and to avoid the leak of the participant's personal information during the transcription participant names will be replaced with code numbers. Thus, the results of the study, published or unpublished, will in no way identify a participant

Moreover, during the research the personal data, tape/photographs/video recordings and transcripts will be stored in a locked desk in the researcher's home or office. Other than the researcher, only the supervisors will have access to the raw data.

In addition, data will be held for the period of the research and will be destroyed after 3 years after the research by shredding, erasing tapes and deleting electronic files.